Chemical Exposition Daily, Sept. 28

CHEMICAL & METALLURGICAL ENGINEERING

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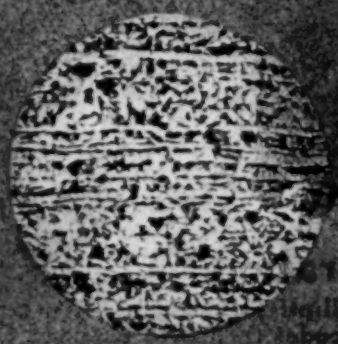
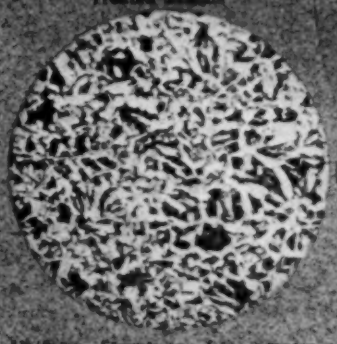
Test Pieces from ⅛" Plate—Bent till Cracks Developed

Microphotographs matched and magnified 150 diameters



Microphotographs etched with nitric acid and magnified 75 diameters



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Titanium Treated
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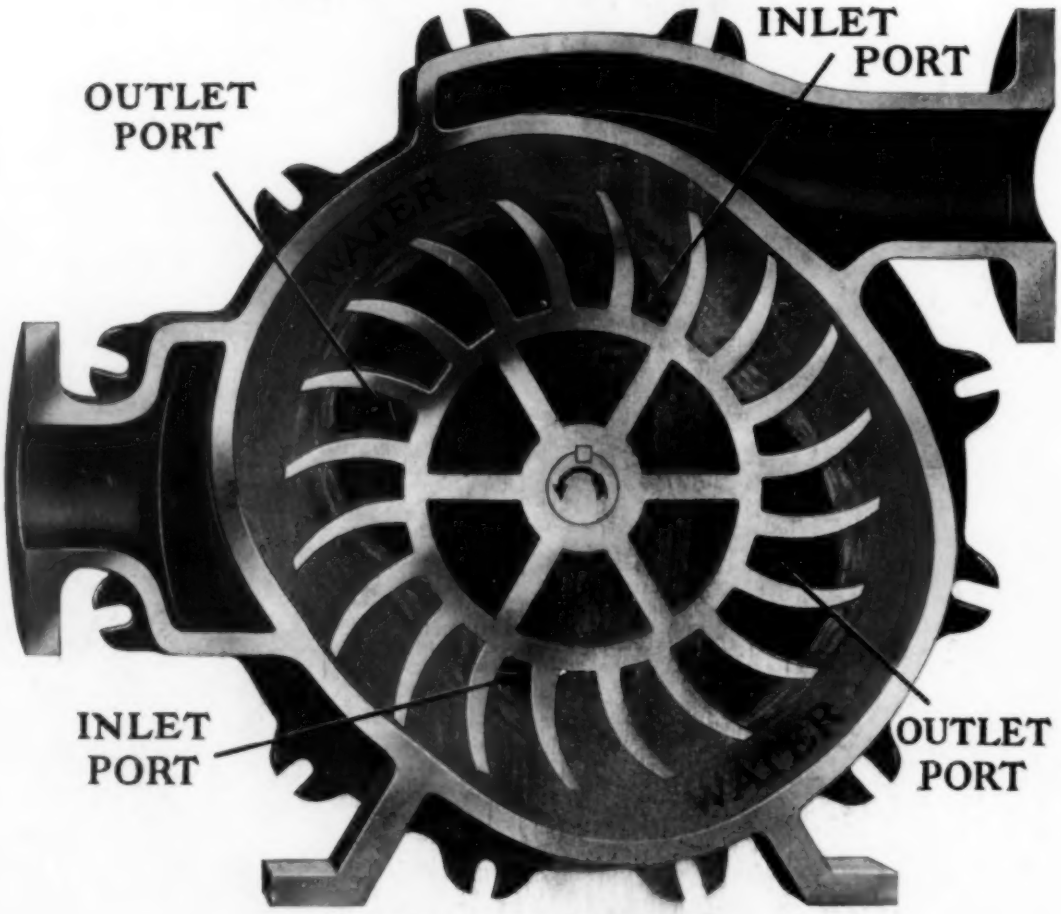

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Germany in The Melting Pot

THE weak spot in Germany's armor at the beginning of the war was in her shortage of the non-ferrous metals. To ameliorate this a national inventory of all the metals was made from which a sort of military registration was evolved of candle sticks, church bells, chandeliers, copper roofs, brass pipes, bronze statues, token coins, etc., with the varying classifications as to their military essentiality. All Belgian articles were given class 1-A immediately. The Hohenzollern and Hapsburg bronze statues were placed at the other end of the line in class 5-G. All others were given intermediate classifications.

All went well during the early days of the draft. The calling out of class 1-A was a jubilant assemblage. Early successes brought in many tons of scrap. The work of reclaiming on the battle-fields became an important factor in the supplies of copper, tin, nickel, etc. However, in spite of all this, the disbursements were so enormous that the draft gradually passed on into the deferred classes. The great classic statues of Schiller and Goethe lost their dignity and their value as scrap-metal soared so high that the labors of the sculptors were petty items on the German account books.

With the cremation of the Schillers and Goethes in the foundry cupolas, for work in the front lines, the wonder soon grew as to why the Friedrichs der Grosses and Wilhelms did not leave their park pedestals, for surely poets were not of greater need at the front than the Deutschland-über-Alles commanders of yore. Indignation among the enlightened population of Germany grew to such an extent that three bronze Hohenzollerns enlisted at Berlin, three more at Cologne, two from Munich and one each from several towns along the Rhine, to save their fame.

Another interesting feature in the German metal situation is the exhalted uses of iron. The military honor crosses of the rusty metal have no more intrinsic material value that the lucky horseshoe of legendary fame. Not satisfied in limiting the iron "toting" to the soldiers, Germany has instituted iron coinage. The fractional mark coins are no longer of copper and nickel but are forgings of Siemens-Martin steel, the nobility of the non-corroding ferro-silicons being too high for the office. Thus the embossed German eagle has been elected to join the Schillers, Goethes, Wilhelms and Friedrichs of the metal world in their new vocations.

The really satisfactory thing about this is the clear evidence afforded of the lack of metals on the other side of the Rhine. The fate of the monuments and coins typifies Germany—all are in the melting pot.

Our Preeminence in Metal Production

IN VIEW of the important part played by metals in the prosecution of the war, it is a significant fact that neither Germany nor Austria holds first rank in the production of a single vital metal. The Allies, on the other hand, not only have the advantage of the United States' leadership in base-metal production, but they also control the output of the precious metals. Taking the latter first, we find that Great Britain controls over 60 per cent of the output of gold, through the mines of South Africa and Australia. The United States leads in silver production. Russia is the most important source of platinum, so necessary for making heavy acids for explosives; and while that unfortunate country may not be a comforting asset just now, there is abundant opportunity to capitalize her metal resources if we proceed in the right way.

Among the base metals, the United States takes first place in the production of lead, copper and zinc, all useful in the manufacture of small ammunition. In iron and steel, also, we have normally led the other nations, producing about 40 per cent of the world's total. This has been of incalculable value in the making of ships, guns and projectiles, and in the tremendous amount of construction that has been under way. Aluminium for light alloys used in aëroplane construction is of vital importance, and here again the United States is the fortunate leader in production. With nickel available in large quantities from the mines of Canada and refineries of our own country, and tungsten from Colorado and California, we have the basis for alloy steels of the first importance. Indeed it would be difficult to find a brighter galaxy, and it is safe to say that no other nation is so favored. The advantage which it represents cannot be adequately estimated because so many factors enter into our ultimate success; but if a careful analysis could be made and reliable values assigned to our various advantages we venture the belief that our preëminence in metal production would stand near the head of the list.

War Minerals Bill Ready for Signature

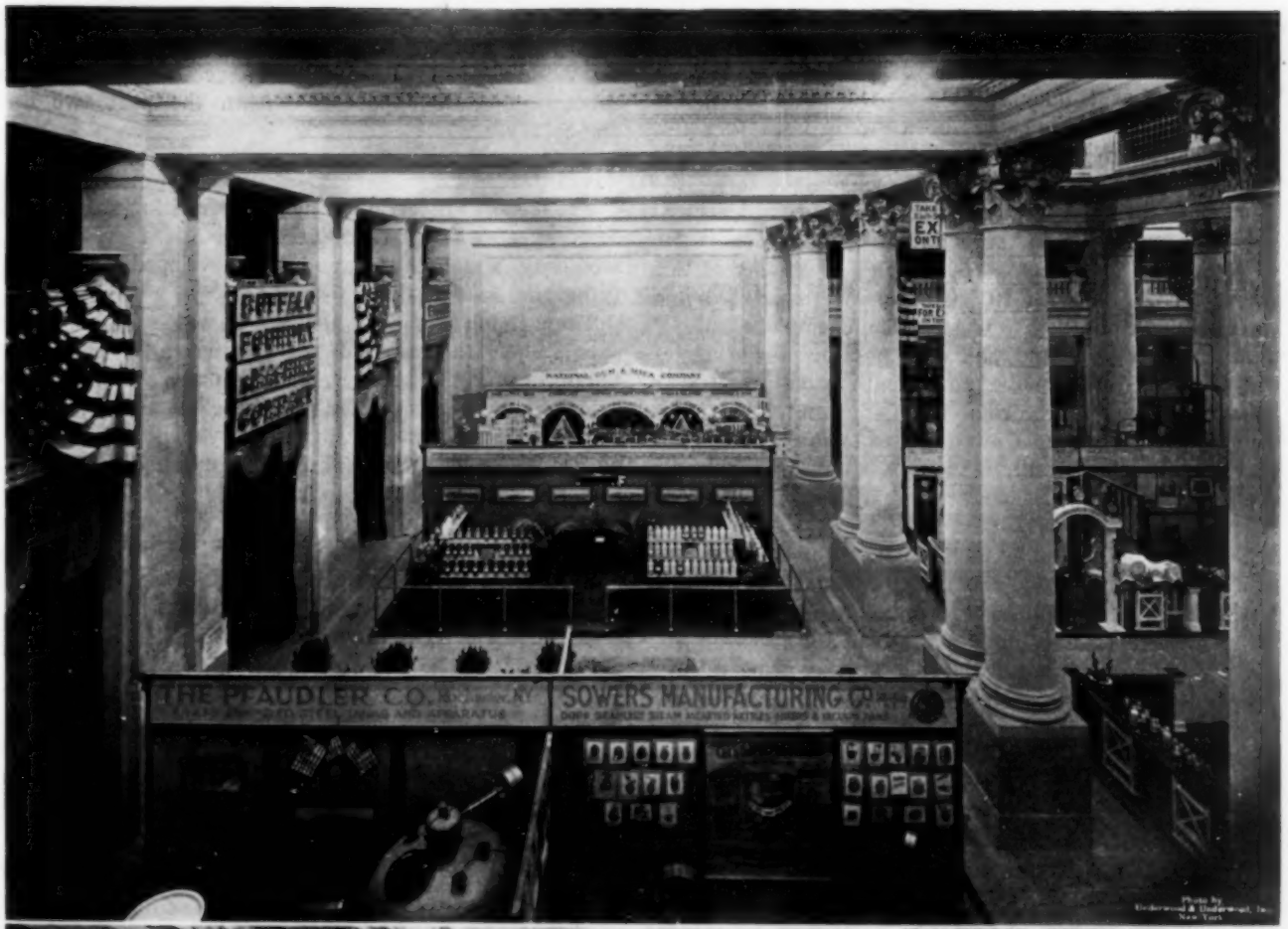
WE WERE advised yesterday that the War Minerals bill, which has been pending for so many months, had finally passed both houses of Congress and awaited the President's signature. It is exceedingly unfortunate that there has been so much delay in passing this needed legislation, for there is no doubt that a great deal of work has been postponed until the attitude of the Government could be determined. There were features in the House bill, however, which became the subject of so much controversy that it soon became apparent that delay was inevitable. The price-fixing and licensing features were the subject of attack, as was also the amount of the revolving fund which had to be provided for operations under the terms of the bill. When the House bill went to the Senate, that body struck out everything following the enacting clause, which is an effective parliamentary procedure in amending a bill, and then added ten sections of its own drafting. The price-fixing feature went by the board; the amount of the revolving fund was changed from $10,000,000 back to the original $50,000,000; provision was made for a system of contracts between producers and the Government; and in general a better bill was drawn up than was conceived by the House. The Senate was more conservative, and yet the hope is expressed that its bill will be quite as effective as the House intended its own should be.

In brief, the bill authorizes the President to enter into contracts for the production or purchase of certain ores, minerals and metallurgical products, and to use, allocate or sell them in the interest of the national security and defense and the successful prosecution of the war. In order that producers shall feel properly safeguarded and warranted in producing materials for sale under the terms of the bill, it is provided that contracts for purchase may cover a period of two years after the end of the war, but not longer. The President is further authorized to requisition and take over the materials under consideration, as well as mines and metallurgical works capable of producing them, and to operate such mines or works in any manner he may deem best. Just compensation is to be made to the parties from whom the mines or works are taken, and provision is made for determining what that just compensation may be, in case agreement cannot be reached without resort to litigation. We fancy that prospect of having to litigate to determine a settlement will not make a strong appeal to those whose mines or works may be taken over.

The sum of $50,000,000 is appropriated as a revolving fund with which to carry out the objects of the bill. Corporations may be formed by the President to facilitate the purpose of the bill, and the United States may subscribe their capital stock from the revolving fund. In such event the President would designate the directors of the corporations, who would hold and vote the capital stock for the exclusive benefit of the United States.

Only a brief survey is required to see that enormous powers are vested in the President, and it is presumed that he will designate certain individuals to exercise these powers for him. Indeed the bill provides for the designation of officers or agents who shall act for the President. In the appointment of these agents will lie the ultimate success of the measure. This was one of the points that caused much discussion over the original House bill which provided for a Minerals Administrator comparable to the Food and Fuel Administrators. The present bill does not contemplate such an official, but there are others that must be appointed, and in their selection the President will have an opportunity to display good judgment. The mining and metallurgical industries have developed some excellent executives and there should be no difficulty in finding good men to fill such places as may be created.

The minerals and metals in the interest of which the bill is drawn comprise a formidable array beginning with antimony and ending with zirconium. In order to meet emergencies, provision is made to include "such other rare or unusual elements" as to which there may be a present or prospective shortage. It remains to be seen whether the assumed need for the bill exists. We believe from many reports received at this office that some federal authority is needed to insure adequate production of certain materials, and in our opinion the desired result should be accomplished by this bill.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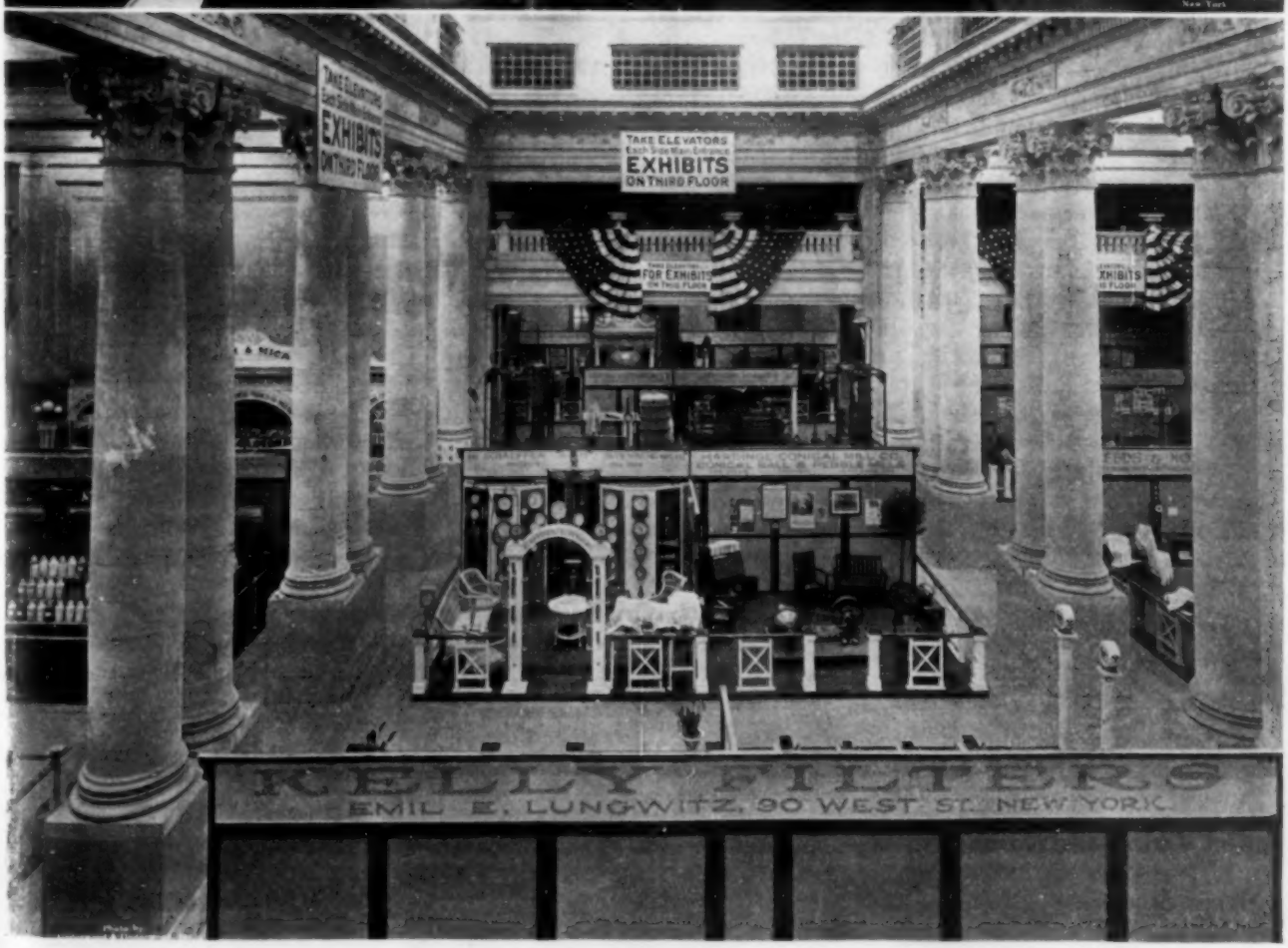
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Sidelights on the Exposition

THE Chemical Catalog Co. of 1 Madison Avenue, N. Y., has a busy exhibit on the main floor, and although it has only copies of a single book to show, the visiting public displays a lively interest in it. The purpose of the book is to tell, in convenient form, the names of all the makers and producers of chemicals and chemical apparatus in the country. Publication began in 1916 with an issue of 8500 copies of a book of 205 pages each. In 1918, 10,200 copies were printed and each volume contains 578 pages. The chemical names of materials are given and, as far as possible, trade names are also set forth, while underneath each product or thing indicated is recorded the name and address of every producer in the United States, so far as diligent search may bring it out. Proper cross references serve the purpose of added elucidation and avoid unnecessary repetition as well.

The book is loaned without charge for one year to professors, consulting chemists, chemical engineers, works managers, manufacturers and others comprising a list of such as may have actual use for it as an aid in buying. To others it is sold at the price of five dollars per copy.

A list of technical books is given at the end with descriptive digests and information as to author, publisher and price.

* * *

That big Hough patent nitrator which the Buffalo Foundry people show is only their medium size, says Mr. Hough. If used for TNT it takes a charge of 25,000 lb. of mixed acid and 2500 lb. of toluene. The 2500 lb. of toluene is run into the acd in 30 minutes and owing to the spray arrangement and the circulation of the acid, every pound of the hydrocarbon meets 3500 lb. of acid. The volume of the nitrating body keeps down the temperature while the flow of the whole over the cooling coils provides that a variation of not over one-half deg. C. takes place between the point of contact of hydrocarbon and acid and the center of the machine.

As the toluene is injected in, the temperature rapidly rises to 50 deg. C. and it is maintained at this point by control of water in the coils, thus producing dinitrotoluene in the first instance—i.e., in the initial half-hour. The cooling water is then shut off and the heat of the reaction carries the temperature up to the "cooking stage," or about 110 deg. C. In three hours more, or within three and one-half hours from beginning the operation, the process is complete and there is produced about 5300 lb. of TNT or, roughly, 85 per cent of the theoretical yield.

Water is sucked and not driven through the cooling coils and litmus indicators are placed at the outlet of each. Then, if a coil leaks, the acid gets into the water and shows itself immediately, whereupon the offending coil may be shut off and no serious harm is done. If the water were driven through the coils and a coil should leak, the water would go into the acid and play the deuce with the reaction. And there would be no indicator to tell the story. Perfectly reasonable, but rather clever, we think. When the machine is set up it is insulated with three inches of asbestos.

The temperature control enables a great variety of nitration processes to be carried on. There is no stuffing box or bearing within the machine. And over 30,000,000 lb. of TNT have been successfully made in several of these apparatus within the past two and one-half years.

* * *

The General Electric Co. has on exhibition some handsome specimens of ferro-zirconium and ferro-chrome-zirconium which they have lately developed with gratifying success.

They show also as a novelty a water japan which should cheer the hearts of the fire insurance men. The japanning ovens of many manufacturing establishments are their danger spots for it is here that fires may get beyond control of the sprinkler system. To this is added the explosion hazard of great quantities of vaporized hydrocarbon or carbohydrate japan solvent mixed with air. The new japan base is a colloid in which the disperse phase is an asphalt and the continuous phase an animal or vegetable oil. By reaction with an alkali a portion of the continuous phase is saponified, whereupon the soap functions as an emulsifying agent. Then, on addition of water, an emulsion is produced in which water is the continuous phase and the japan base the disperse phase. Droplets of the latter are negatively charged and adhere to the positively charged metal in a practically anhydrous state. After baking, the japan is adherent and insoluble in water. Before baking, the japan may be applied with a brush or articles may be dipped in the emulsion, heated to the boiling point of water to give it the proper consistency.

* * *

We have yet to learn of anybody who has worked with Dr. Allen Rogers who did not grow to like him. The Pratt Institute boys who have taken his course in industrial chemistry hover about him whenever they get a chance after they have graduated, and men who have been assocated with him on committees or otherwise are likely to respond, if asked to name a good man to undertake a task that requires reasonableness and intelligence and the avoidance of trouble, "Can't you get Allen Rogers?" Now he is in the army in the Chemical Warfare Service, with the slim waist and springy step that they all seem to achieve; and he has a gold leaf on each shoulder, because he is Major Rogers withal, connected with the Relations Section. His name is on the top of a paper given out by the Chemical Warfare Service and under it are recorded the following activities:

The allocation of enlisted men atfer the war.

Answers to appeal for advice from chemists and from manufacturers.

Transfers of men in the service on indefinite furlough, which is divided under two heads: those not formerly employed where they are needed and those that were.

Deferred classification of chemists and skilled workmen.

Any one of these problems looks to us like a man's job, and if Uncle Sam had com around to ask our advice as to a good man to look after these things; somebody with a heart and a sense of humor and a head that doesn't swell up or run away or topple over, we should have said, as we have said before; "Can't you get Allen Rogers?"

The Ferro-Alloys*

A Brief Description of the Manufacture, Properties and Uses of the Alloys of Iron with Manganese, Silicon, Aluminium, Chromium, Tungsten, Molybdenum, Vanadium, Titanium, Boron, and Uranium

By J. W. RICHARDS[1]

A LARGE industry has grown up within the last fifty years, most of it within the last twenty-five years, which furnishes to steel makers alloys of iron with some of the rarer metals, in order to introduce these rare metals into steel. Such alloys are known as ferro-alloys, because they all contain iron (ferrum); some of them, however, contain more of the rare metal than iron. They were originally made in crucibles, cupolas or blast-furnaces, but are now made principally in electric furnaces, and their manufacture is one of the principal electric-furnace industries.

They are of great importance to the steel industry. The steel maker uses them for one of two purposes: (1) As reagents to take oxygen out of melted steel and thus insure sound solid casting (ferromanganese, ferrosilicon, ferroaluminium); or (2) to put into the steel a small or large percentage of the rare metal (ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, ferrotitanium, ferrouranium, ferroboron).

Let us discuss briefly these two uses. Melted steel, just before taking from the furnace, always contains some oxygen dissolved in it (like the dissolved gas in charged soda water). If this is not removed, the casting made is more or less unsound from cavities or blowholes. The addition of a small amount of a metal with a high affinity for oxygen removes this element and makes the casting sound. Manganese (1 per cent or less) is the cheapest and most generally used reagent for accomplishing this; silicon (½ per cent or less) is more powerful but also more expensive, and is often used to supplement the action of manganese; aluminium (0.1 per cent or less) is still more powerful and still more expensive, and is used in very small quantities as a final addition to complete the action of the manganese and silicon. All steel makers use one, two or all three of these reagents; manganese and silicon in the form of ferro-alloys, aluminium more ofter as the pure metal, but ferro-aluminium is sometimes used.

The second use is to make special steels, that is, steels containing such quantities of the rare metal as give to them properties different from plain carbon steels deoxidized by manganese, silicon or aluminium. Thus we may make manganese steel by putting in 12 to 14 per cent of manganese, making a very tough, hard steel such as is used in mining and grinding machinery, burglar-proof vaults etc.; chromium (2 to 4 per cent) makes a very hard tool steel; tungsten (15 to 25 per cent) makes high-speed tool steel, which cuts iron while red-hot; molybdenum (6 to 10 per cent) has powers similar to tungsten, and is also used in steel for lining large guns. Vanadium (1/10 to ½ per cent) makes very strong steel which resists shock extremely well, as when used for automobile axles; titanium, uranium and boron impart valuable properties not so easily described. Every one of these materials is used for producing some specific result which is not produced by any other; sometimes combinations of two, three or four are used in one steel, producing a particular combination of special properties for some special purpose. Some of these materials cost $5 per pound, and the special steels produced cost up to $2.50 per pound, but their particularly valuable properties justify the expense. The value of these special steels to the industries, and particularly for military purposes, is very great, so great that the supply of ferro-alloys for their manufacture is an important factor in winning the war.

Ferromanganese

This is the oldest of the ferro-alloys. Its manufacture was begun about 50 years ago. It was first made in crucibles, has for a long time been made in blast-furnaces, but is now being produced in many places in electric furnaces. It is made with 30 to 85 per cent manganese, 3 to 5 per cent carbon, a little silicon and the rest iron. The rich grades, 75 to 85 per cent, are preferred by the steel maker, but they require rich manganese ores for their manufacture. The United States has very little rich manganese ore, but large quantities of low-grade ores; one of the present burdens of the steel maker is to use low-grade ferromanganese, in order that we may not have to use ships for importing the high-grade ores from Brazil.

The usual manufacture in blast-furnaces is wasteful of both fuel and manganese; the furnace must be run hot and slowly, with very hot blast in order to reduce the manganese oxide ore as completely as possible and not waste manganese in the slag. Yet, in spite of all efforts, from 15 to 25 per cent of the manganese going into the furnace escapes reduction and is lost in the slag. This waste of fuel and manganese has led to the use of the electric furnace, in which fuel is required only as a chemical reagent and not to produce heat, thus saving about two-thirds the fuel requirements of the blast furnace, while the higher temperature available causes the extraction of manganese to reach 90 per cent, i.e., slag losses to be down to 10 per cent or less. Against these economies must be set the considerable expense for electric power and the smaller scale on which the furnaces run. At the present high prices of coke and manganese ore, and in view of the scarcity of manganese and the high price of ferro-

*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 27, 1918.

[1]Professor of Metallurgy, Lehigh University; Secretary, American Electrochemical Society; Member, U. S. Naval Consulting Board.

manganese, the electric ferromanganese industry is able to exist and make large profits. Whether it can do so when normal conditions return, after the war, is questionable; it is to be hoped that it will be able to do so, because of the economy which it undoubtedly possesses in regard to fuel and manganese.

Steel producers use ferromanganese particularly for making the low carbon or soft steels, because they can thus introduce the required manganese for de-oxidation without putting in considerable carbon. For higher carbon steels spiegeleisen (15 to 20 per cent manganese), a cheap blast-furnace alloy, can be used, and is being used at present wherever practicable, in order to save ferromanganese. The best practice with either spiegeleisen or ferromanganese is to melt them in a small electric furnace, and tap from it the required weight to be added to the heat of steel. The melted alloy mixes quicker with and reacts more actively upon the melted steel, while less of it is necessary because less is oxidized by the furnace gases. The saving in manganese by the use of the electrically-melted ferro is alone sufficient to justify the expense of melting it in an electric furnace, while better and more homogeneous steel is produced.

Ferrosilicon

This alloy may run 15 to 90 per cent silicon, but the most commonly used is the 50 per cent grade. It is made from ordinary silica (quartz or sand), reduced by carbon in the presence of iron ore or scrap iron. The blast furnace is able to make only the lowest (15 per cent) grade, because silica is exceptionally difficult to reduce, and under conditions which would reduce 99 per cent of the iron ore in a furnace, or 75 per cent of the managnese ore, only 15 to 20 per cent of the silica present can be reduced, and only a low-grade silicon alloy produced. The higher grades must all be produced in the electric furnace.

The raw materials are ordinary silica, the most abundant metallic oxide on the earth's surface, iron ore or scrap iron (iron or steel turnings or punchings), and coke. Electric furnaces up to 10,000 hp. have been operated on ferrosilicon (50 per cent grade). At the high temperature required, a not inconsiderable proportion of the reduced silicon vaporizes, and burns outside the furnace to a white silica smoke. This can be largely prevented by skillful furnace supervision. In normal times, the 50 per cent alloy sells at $45 to $50 per ton, which is a low price for an alloy so difficult to produce.

Steel producers use ferrosilicon principally for the great activity with which the silicon removes dissolved oxygen from the steel. It is about four times as active as manganese in thus reducing blow-holes and producing sound castings. It is usual, however, to use manganese first, to do the bulk of the deoxidation, and silicon afterwards to finish up the reaction more completely. It is particularly useful in making sound steel castings which are cast into their ultimate form and do not have to be worked into shape, because a slight excess of silicon may make the steel hard to forge or roll, whereas an excess of manganese does not have so bad an effect on the working qualities. A particular kind of steel called silicon steel carries 1 to 2 per cent of silicon and yet forges well; this would be classed as a special steel.

The ferrosilicon industry has attained large proportions in countries where electric power is cheap, particularly therefore in Switzerland, the French Alps, Norway, Canada, and parts of the United States. Under present conditions it is even profitably run where electric power is relatively dear, as at Anniston, Ala., and Baltimore, Md. It is a large, interesting, and rapidly growing industry.

Ferro-aluminium

This alloy, with 10 to 20 per cent of aluminium, was made in the electric furnace and used in considerable quantity in steel about 1885-88, but was displaced by pure aluminium as the latter became cheaper. Aluminium is about seven times as powerful as silicon and twenty-eight times as strong as manganese in acting upon the oxygen dissolved in steel; therefore only minute quantities are necessary, say one ounce up to a maximum of one pound of aluminium per ton of steel Its use gives the finishing touch to the de-oxidation of the steel.

About 1885 the Cowles brothers, operating the first large electrical furnaces run in America, at Lockport, New York, made and sold considerable quantities of ferroaluminium, selling the aluminium in it at the rate of about $2 per pound, while the pure metal was then costing $5. When, a few years later, pure aluminium sold for 50 cents per pound, the steel makers turned to using the pure metal instead of ferroaluminium, and at the present time aluminium is so used in practically every steel works in the world.

There seems to me a distinct opportunity for makers of ferro-alloys to revive the manufacture and sale of ferroaluminium. Such great advances have been made in the construction and operation of large electric furnaces since 1890, and so much experience has been had in reducing the difficult oxides to ferro-alloys, that the production of 50 per cent ferroaluminium at say $100 per ton may be a distinct electric furnace possibility. That would furnish the contained aluminium at about 10 cents per pound, as against 30 cents for the commercial aluminium now used. The alloy should be broken up small before using, and thrown in the runner or on the bottom of the ladle, in order that the melted steel may quickly dissolve it as it runs into the ladle.

Such ferroaluminium would require bauxite with iron ore or scrap iron, for its manufacture, but there are large deposits of low-grade bauxite rich in iron, in Southern France, which could be reduced directly to the alloy without any additions, and thus furnish very cheap raw material for the operation.

In conclusion, ferroaluminium is not now being made, but its electric furnace production is a real possibility.

Ferrochromium

Ferrochromium is used for making what is familiarly but erroneously called "chrome steel." It makes steel exceedingly hard. Very hard cutting tools, and armor plates to resist projectiles, are made of it. Only 2 to 4 per cent of chromium may be used.

Several grades are made in the electric furnace, depending on the per cent of chromium (25 to 75), and

the content of carbon (2 to 8 per cent). This alloy takes up carbon so actively in the furnace that it has to be treated subsequently to remove the carbon down to what can be endured by the steel into which it is introduced.

The raw material for its manufacture is chromite, an oxide ore of both chromium and iron. If this is mixed with carbon and smelted in the electric furnace it reduces directly to ferrochromium alloy (often misnamed "ferro-chrome"), and highly saturated with carbon (6 to 10 per cent). Steel makers want lower carbon than this, so the alloy is re-melted with more chromite in another furnace, and the excess of carbon oxidized out. The low-carbon alloy sells for 2 to 3 times the price of the high-carbon crude material.

The cutting off of importations of high-grade chromite ore from Asia Minor has led to intense prospecting in the United States. Fair material has been found in many places, and at present our country is nearly independent of foreign sources of the ore.

Ferrotungsten

Tungsten (also called wolfram) imparts curious and valuable properties to steel. A small amount (2 to 5 per cent) has been used for half a century or more, to make the steel self-hardening; that is, a tool of this steel need only be let cool in the air, and it becomes hard without the ordinary quenching or chilling operation. Larger proportions (10 to 25 per cent) make a steel which stays hard even when red hot. A tool of this material can be run so fast on a lathe, for instance, that it gets red-hot from the friction and work, yet keeps hard and keeps on cutting. It is called high-speed tool steel, and its use alone has more than doubled the output capacity of the machine shops of the world.

The ore used in either wolframite, a black oxide of iron and tungsten, or scheelite, a white oxide of calcium and tungsten. It is found in considerable quantities in Colorado, and some other Western States, and imports of this ore have not been necessary during the war. In this respect we are much more favorably situated than the European nations. A plentiful supply of tungsten ore may indeed be regarded as a large factor in the production of cannon and fire-arms and all kinds of machinery, and therefore a considerable factor in winning the war.

Ferromolybdenum

Molybdenum has only recently come into large use in steel. Its action being somewhat similar to that of tungsten, scarcity of the latter metal, particularly in Europe, has led to the manufacture of ferromolybdenum on a comparatively large scale.

The ores are widely distributed but not very plentiful. Molybdenum sulphide, molybdenite, looks almost exactly like shiny graphite but it is a shade lighter in color and nearly twice as heavy. It occurs usually as flakes in granite rock and might easily be mistaken for graphite. Lead molybdate, wulfenite, is a compound of lead and molybdenum oxides, a very prettily crystallized yellow to red mineral in thin square plates. It occurs abundantly in a few lead mines in the West. It is usually first treated to extract its lead, and the residue then worked for molybdenum. The sulphide used to be roasted to molybdenum oxides, and this reduced by carbon in the presence of iron ore or scrap iron in an electric furnace. It is now smelted directly in the electric furnace with carbon and a large excess of lime along with iron ore or scrap iron. Ferro with 50 to 60 per cent of molybdenum is tapped from the furnace like other ferro-alloys, but with molybdenum up to 80 per cent the alloy has such a high melting point that it cannot be tapped out without freezing; it is necessary to make a furnace full of this alloy and then let the furnace cool down and take it apart, taking out a large mass of solidified alloy; the furnace is then rebuilt.

The large use of molybdenum in steel has been so recent that not much has been made public about it. Rumor says that the large German guns which bombarded Liege (the "Black Berthas") were lined with molybdenum steel (6 to 7 per cent) to increase their resistance to erosion. It seems certain that Germany drew considerable supplies of molybdenite from Norway to compensate for shortage of tungsten for high-speed tool steel. Parts of guns, gun carriages, motors, automobiles, have also been made of molybdenum steel of most excellent quality. Canada has been especially active in the manufacture of ferromolybdenum steel, most of which is exported to Europe. This alloy is therefore another valuable war material.

Ferrovanadium

Without vanadium the modern automobile or autotruck would be a much weaker machine. When steel is desired to withstand the heaviest shocks and vibration, nothing is quite so effective as adding vanadium. This is another comparatively rare metal, found principally in the radium ores of Colorado and as a black sulphide on the highlands of Peru. The canary yellow Colorado ore is treated for radium, and the residues for vanadium and uranium. The U. S. Government (Bureau of Mines) operated this process for the radium supply. The black ore of Peru is rich and unusual; it is a sulphide with some asphaltic matter, and it is roasted to the condition of iron-vanadium oxide before reduction. The oxides are best reduced by metallic aluminium. This is the well-known thermit (Goldschmidt) method of reduction. Electric furnace reduction by carbon is not advantageous because of the large amount of carbon taken up by the alloy; powdered silicon is therefore put into the charge as the reducing agent, together with iron, lime and fluorspar, and then a 30 to 40 per cent vanadium alloy is obtained with seldom over 1 per cent of carbon, a very desirable composition (R. M. Keeney).

Only small amounts of vanadium are necessary to improve steel; 0.1 to 0.4 per cent are the usual quantities. This is fortunate because the vanadium costs $5 per pound and over. Metallurgists suspect that part of the improvement of the steel may be due to the vanadium combining with and removing nitrogen dissolved in the melted steel. This is probably true, yet some advantage undoubtedly must be ascribed to the final vanadium content in the steel; both avenues of improvement function. Steels thus treated are unusually resistant to shock and alternate stresses, making them very useful for axles, cranks, piston-rods, and such severe service.

Ferrotitanium

Titanium is an abundant element in nature. It occurs in immense amounts as a double oxide of titanium and iron, known as ilmenite, or titanic iron ore. This ore can be reduced directly by carbon in electric furnaces to ferrotitanium. The reduction proceeds easier if some aluminium is put in as a reducing agent, but this is expensive and unnecessary. The alloy running 15 to 25 per cent titanium is sold for use in steel as a refining agent to remove oxygen and nitrogen. Thousands of tons of steel for rails has been thus treated, the tests showing considerable improvement in the mechanical properties by the use of quite small amounts (0.10 to 0.20 per cent) of titanium.

Ferroboron

This is another alloy whose valuable qualities have not yet been entirely determined. Boron is the metallic base of borax, which is a sodiumboron oxide. Borax is very difficult to reduce to the metallic state. Another raw material, not so abundant, is colemanite, containing lime and boron oxide. Many attempts have been made, none very successfully, to reduce this with iron oxide to ferroboron. The American Borax Co. offered a prize, for several years, for a process which would accomplish this. Boron oxide occurs rarely in nature, but it can also be manufactured from borax and colemanite. When the oxide is obtained, this can be combined with iron oxide and the resultant boron-iron compound reduced by carbon in the electric furnace to ferroboron. Small quantities of this alloy have thus been manufactured.

Experiments on steel have shown that ferroboron acts somewhat similarly to ferrovanadium. Experiments in France showed remarkably strong and tough steels were thus made, using 0.5 to 2 per cent of boron. The results have not been properly followed up, partly on account of the difficulty in getting ferroboron; no one, as yet, has taken up its regular manufacture and steel makers can hardly be blamed in these stirring times for not having as yet thoroughly explored its possibilities as an addition to steel.

Ferro-uranium

This is the latest of the ferro-alloys to enter the lists. Uranium is a very heavy and, chemically, very active element. It is found very scarcely as a black oxide, the mineral pitchblende—the mineral in which radium was first discovered. It is found more abundantly in the Colorado radium ore, a bright yellow oxide and silicate of vanadium, uranium and lime. After extracting the radium and vanadium, the uranium remains in the residue as a by-product, usually as a soda-uranium compound. This is treated so that uranium oxide is obtained, and this can be reduced by carbon in an electric furnace in the presence of iron ore or scrap iron, to ferrouranium (30 to 60 per cent). The recovery of uranium is not high (50 to 70 per cent) the rest being lost in the slag. Mr. R. M. Keeney has recently described these processes in detail, for the first time in the August *Bulletin* of the American Institute of Mining Engineers.

The results of tests showing the influence of uranium on steel are not yet completely known. Some firms have claimed for it wonderful strengthening power and resistance to shock. The subject is still receiving expert attention from steel makers, and valuable results are confidently expected.

Conclusion

The ferro-alloys are exceedingly important materials to the steel maker, either in the making of ordinary steel or for producing special alloy steels. They are indispensable to the steel industry. They are important factors in producing both ordinary and fine steels, and therefore in winning the war. The country well supplied with them has a great advantage over the country in which they are scarce. They are deserving of all the expert attention which they are receiving from the War Industries Board, the steel makers, and the economists. The possession by the United States of large supplies and resources in the ferro-alloy line, may be one of the important factors in determining the quick ending of the war.

Spelter Specifications

The percentage of impurities in the four commercial grades of spelter have been compiled by C. E. Siebenthal of the U. S. Geological Survey from the following specifications:

1. Am. Soc. Test. Mat. Proc; vol. 11, pp. 147-149, 1911: Adopted August 21, 1911.
2. Am. Soc. Test. Mat. Proc; vol. 16, pp. 583-589, 1917. vol. 17, pp. 180-181, 1917.
3. Navy Department Specifications, 47Zld, June 1, 1917.
4. U. S. Army, Ordnance Department Specifications, Revised March 7, 1918.
5. Navy Department Specifications, 47Zlb, Nov. 1, 1913.
6. New York Metal Exchange Specifications; American Metal Market, August 31, 1916.

Specification	Zinc, min.	Cadmium, max.	Iron, max.	Lead, max.	Cadmium, iron, lead, max. sum	Aluminium, max.	Other elements
A. High Grade							
1	.....	0.05	0.03	0.07	0.10	0	...
2	.....	0.07	0.03	0.07	0.10	0	...
3	99.85	0.05	0.03	0.07	0.10	0	0
4	99.50	0.50	0.03	0.10	0.50	0	0
B. Intermediate							
1	.....	0.50	0.03	0.20	0.50	0	...
2	.....	0.50	0.03	0.20	0.50	...	...
3	99.35	0.50	0.03	0.20	0.50	0	Tr
4	99.35	0.50	0.03	0.25	0.65	0	Tr
C. Brass Special							
1	.....	0.75	0.04	0.75	1.20	0	...
2	.....	0.50	0.03	0.60	1.00	0	...
2	.....	0.75	0.04	0.80	1.25	0	...
3	98.00	0.75	0.08	1.00	1.50	Tr	Tr
4	98.00	0.75	0.08	1.00	1.50	Tr	Tr
5	98.60	0.75	0.04	0.75	1.20	Tr	Tr
D. Prime Western							
1	.....	.....	0.08	1.50	.....	...	...
2	.....	.....	0.08	1.60	.....	...	...
5	98.00	0.75	0.08	1.50	2.00	Tr	Tr
6	.....	.....	0.08	2.00	.....	...	...

Spelter Prices in New York

Following are the New York spelter prices, 1914-1918:

	1914	1915	1916	1917	1918
Jan.	5.33	6.52	18.18	9.97	7.88
Feb.	5.46	8.86	20.09	10.49	7.91
Mar.	5.35	10.12	19.10	10.82	7.60
April	5.22	11.51	18.61	9.73	7.00
May	5.16	15.82	15.93	9.48	7.34
June	5.12	22.62	12.80	9.45	8.04
July	5.03	20.80	9.7p	8.82	9.71
Aug.	5.63	14.45	9.10	8.48	9.08
Sept.	5.52	14.49	9.23	8.26	9.59
Oct.	4.99	14.07	10.01	8.12	
Nov.	5.15	17.04	11.92	7.90	
Dec.	5.67	16.91	11.28	7.77	
Av.	5.30	14.44	13.75	9.11	

Speeding Up Metallurgical Analysis

Pertinent Comments on the Analyst's Part in Production—Selection of Methods That are Rapid and Accurate—Arrangement of the Laboratory is Important Factor

By HAROLD C. PARISH

IN THESE days of intensive production it becomes not only a necessity but the patriotic duty of every chemist engaged in analytical work to produce results in the shortest possible time. In order to do this he must make use of every legitimate short-cut and so plan his work that every moment is utilized to the best advantage. In laboratories where the nature and volume of work received each day is comparatively uniform and where the work can be reported in the order received, this is a comparatively simple matter. In laboratories where this is not true, the problem becomes more complicated. In many laboratories the chemists are often required to report the work received on a given day ahead of that coming in the previous day. This so-called rush work upsets the routine considerably and tends to decrease efficiency.

There are several factors which are involved in the problem of speeding up metallurgical analysis, chief among which are the following:

1. Convenient and efficient arrangement of hoods, benches, sinks, apparatus, and chemicals.
2. The proper preparation of samples.
3. Selection of such methods of analysis as will give the required degree of accuracy in the shortest space of time.
4. Planning of the work in such a way as to make every minute count.
5. Handling of the common laboratory manipulations involved in such a way as to produce maximum efficiency.

Arrangement of the Laboratory

It will be obvious that it is impossible to offer other than very general suggestions for the laboratory layout on account of variations in conditions in different laboratories as regards amount of available space and facilities. It should be the aim to have the arrangement as compact as possible and designed to save steps. Whenever possible, it will be found convenient to have the hood situated back of the worker. In any event, it is essential in a properly arranged laboratory to have hoods centrally located and of ample proportions. This is equally true of benches, sinks and balances. Obviously, the balances should be protected from laboratory fumes. The author has found it convenient to place standard solutions on a shelf above the working bench and to have the bottles or carboys containing these solutions connected with their respective burettes in such a way as to feed by gravity.

The burette stands may be set back on a bench out of the way. There should be sufficient cupboard and drawer space underneath the benches to contain apparatus in constant use. Small reagent bottles containing ammonia, the mineral acids and any other chemicals in frequent use are best located on a small shelf above the working bench and plainly labeled. Stock reagents should also be kept near at hand. Space should be provided for as much permanent apparatus as possible. Probably as much valuable time is lost in many laboratories in setting up and dismantling apparatus every time certain determinations are made requiring special apparatus as in any other way.

Preparation of Samples

It is obvious that the condition of samples has considerable influence upon the speed of weighing and the solution of these samples in acids. It is a very difficult matter to weigh or dissolve coarse samples rapidly. Furthermore, the accuracy of many methods depends upon the comparatively fine division of the samples. For sampling soft white metal alloys a coarse rasp or a hack saw gives a very satisfactory sample. A hack saw may also be used for sampling copper, brass or bronze. These latter alloys, as well as iron and steel, may also be sampled to good advantage with a flat or a twist drill which has the sharp edge of the lip slightly dulled by grinding. This treatment of a twist drill eliminates coarse curly drillings. Obviously, care should always be taken to obtain representative samples. In determining carbon in steel or iron the author uses only those drillings which pass a 20- and remain on a 60-mesh sieve. In this way very excellent results may be obtained.

Selection of Methods of Analysis

It is a deplorable fact that a large number of chemists are using the longer methods of analysis when results of equal and sometimes greater accuracy could be obtained by the use of shorter ones. Every chemist should be alive to this vitally important phase of the problem and always be on the lookout for shorter methods of analysis or means of eliminating unnecessary steps in procedures already in use. If he is not certain of the accuracy of a method new to him, he should check it thoroughly against one known to be reliable. Published methods of procedure are too often followed mechanically without a thought as to whether or not they can safely be shortened. A little experimental work would often point out modifications which would not interfere with the accuracy of the analysis. Maximum accuracy required plus maximum speed should be the aim of every analyst.

It may be of interest to mention methods used in iron and steel analysis which seem to give this desirable combination. No attempt will be made to go into detail except in one or two instances, as most of the procedures are so well known by name that no description is necessary. Shorter methods have been tried in many instances, but have not been adopted because they did

not prove reliable. Some readers may be using procedures which are still shorter and give equally accurate results. If so, they should certainly publish them in the interests of efficiency if they have not already appeared in the literature. The following is a list of methods used in this laboratory in steel analysis.

Silicon. Drown's method.

Manganese. Bismuthate-arsenite.

Phosphorus. Alkalimetric titration of the ammonium phosphomolybdate.

Carbon. Direct combustion at 1000 deg. C. and absorption of CO_2 in 12-mesh soda-lime containing 15 per cent water.

Sulphur. Evolution method. Precipitation of H_2S as cadmium sulphide and titration with standard iodine solution.

Chromium. A further modification of "Barba's Modifications" described in Blair's "Analysis of Iron."

Nickel. A modified cyanide method.

Vanadium. Johnson's method, titrating with ferrous ammonium sulphate, using potassium ferricyanide as an indicator.

Tungsten. Rapid method described in Blair's seventh edition, page 204.

A description will be given of the methods mentioned above for chromium and nickel. A few suggestions for saving time in operating some of the other methods may be helpful to someone.

Carbon. The only point that suggests itself regarding the determination of carbon is that time can be saved by weighing all of the determinations to be made for the day in one sitting. In this way there will always be a sample ready to put into the furnace as soon as another one is taken out and there will be less interference with other work.

Silicon. The method of Drown calls for the solution of the sample in a mixture of nitric and sulphuric acids, evaporation to the evolution of SO_3 fumes, solution of residue in water or dilute HCl, filtration of SiO_2, ignition and weighing. In this determination the SiO_2 can be filtered much more rapidly if the residue is dissolved as soon as possible after evaporating to fumes and filtered immediately while still hot. If the washing of SiO_2 with dilute HCl and hot water is sufficiently thorough, it should not be necessary to make an evaporation with HF after ignition and weighing. If the SiO_2 is not pure white, however, after ignition, this evaporation must be resorted to. One weight can be avoided by carefully brushing the SiO_2 into balanced watch-glasses instead of weighing the crucible.

Manganese. The determination of manganese is carried out just as described in Blair's seventh edition, page 122, up to the point of titration, when standard sodium arsenite is used as described in Lord & Demorest's "Metallurgical Analysis" under the "Bismuthate-Arsenite" method. A porous alundum thimble is used for filtering the solution by suction previous to titration.

Phosphorus. The alkalimetric determination of phosphorus in iron and steel is equally as accurate as the Emmerton process of reducing a solution of the ammonium phosphomolybdate with zinc and titrating with $KMnO_4$, and everyone who has used both methods will agree that much time can be saved by using the former.

Sulphur. Where many sulphur determinations are made it is best to have a sulphur rack built and connected with the gas supply as a permanent laboratory fixture. The number of determinations which it should accommodate at one time depends, of course, upon the volume of work handled each day. The one the author uses carries ten.

Chromium. Barba's modification, referred to above and described on page 197, Blair's seventh edition, calls for the addition of a comparatively large excess of $KMnO_4$ to oxidize chromium after the solution and oxidation of a 1½-gram sample with HNO_3. This excess is destroyed with ammonia, the solution again acidified with H_2SO_4, boiled, MnO_2 filtered off, aliquot taken representing 1 gram and the solution titrated with standard ferrous ammonium sulphate and potassium permanganate.

The author has for some time used a modification of this method which has served for several hundred determinations and been found to give results equally accurate and to be more rapid. A 1-gram sample is dissolved and oxidized with nitric acid, exactly the same as described by Blair. After the oxidation the solution is then diluted to approximately 100 cc., brought to a boil, and while boiling, a saturated $KMnO_4$ solution is added a few drops at a time from a pipette, the solution being warmed between each addition, until a permanent precipitate of MnO_2 is obtained. The solution is then boiled for 15 or 20 minutes, or until upon removal from the application of heat the precipitate settles rapidly leaving a clear yellow supernatant liquid free from pink tints. The solution is cooled, filtered and titrated as usual with ferrous ammonium sulphate and potassium permanganate.

If vanadium is desired, the pink produced by the $KMnO_4$ should be just destroyed with the ferrous ammonium sulphate solution, exactly 2 cc. of a 2 per cent potassium ferricyanide indicator added and the vanadium titrated with ferrous ammonium sulphate to the destruction of yellow tints, according to Johnson.

Nickel. Several years ago Mr. Arthur G. Carman, formerly connected with this laboratory, worked out a modification of the cyanide method which the author believes to be the most rapid method in use for this determination. The method is carried out as follows:

Dissolve 1 gram of steel drillings in a 400-cc. beaker with 20 cc. 1:1 HCl. When action ceases, add 10 cc. of 1:1 HNO_3. Boil until the red fumes have been driven off and the carbon is completely destroyed. Add 100 cc. of citric acid solution, dilute to 300 cc., and add with a pipette exactly 5 cc. of standard $AgNO_3$ solution. Now add just sufficient ammonia to destroy cloudiness, then 2 cc. of KI solution and titrate with standard KCN solution to the disappearance of turbidity. This titration is best done by transmitted artificial light, placing the beaker on a piece of black glazed paper. The end point is easy for an experienced operator to detect and is not reached as long as a drop when striking the solution produces a spot clearer than the solution around it. As soon as the end point is reached all turbidity will have disappeared. If it is thought that the end point is passed, add a measured amount of $AgNO_3$ solution until turbidity just appears. It is best to have another beaker containing a solution

to be titrated, to which no $AgNO_3$ has been added, placed beside the one being titrated so as to have a clear solution for comparison. If the citric acid was dirty, the solution will be cloudy and should be filtered before the $AgNO_3$ is added.

Solutions:

$AgNO_3$. Dissolve 2.885 grams of C.P. $AgNO_3$ in water and dilute to 1000 cc.

KI. Dissolve 50 grams of C.P. KI in 250 cc. of water.

Citric Acid. Mix 380 grams of C.P. ammonium sulphate, 270 cc. of concentrated ammonia, 1430 cc. of water, and 240 grams of citric acid.

KCN. Dissolve 8.85 grams of pure, or 9.03 grams of 98 per cent KCN and 10 grams of KOH in water and dilute to 2000 cc.

Standardization. The KCN solution is most conveniently standardized against a U. S. Bureau of Standards 3.50 per cent nickel steel, the same procedure being followed as above. An additional titration must be made in order to obtain the relation between $AgNO_3$ and KCN. This is accomplished in the solution after titration for standardization by adding exactly 10 cc. standard $AgNO_3$ to solution and running in standard KCN to disappearance of turbidity. One-half of the amount of KCN required is to be subtracted from the amount used in each determination.

Notes:

1. The presence of sulphates is necessary to obtain a sharp end reaction. AgI is soluble in a large excess of NH_4OH, so care should be taken to have the solution only slightly alkaline with NH_4OH.
2. If the titrated solutions are allowed to remain in open beakers for some time, a white film forms on the surface but no account is to be taken of it.
3. When chromium is present in appreciable amounts the same procedure is followed, except that it may be necessary to add a little more citric acid solution in order to hold the chromium in solution when ammonia is added.
4. The $AgNO_3$ solution used should not be stronger than that indicated above, for when a stronger silver solution is used, the AgI instead of forming a turbid solution settles out as a curdy precipitate which does not readily react with the cyanide. If a ferro-nickel is being analyzed a stronger solution of KCN should be used.
5. Such elements as V, Cr, W, Mo or Mn do not interfere even when present in large amounts in the sample. Copper, however, is titrated with KCN but is usually present in negligible quantities. If its presence is suspected, nickel should be determined by the dimethylglyoxime method.

Vanadium. This method will be found described in Johnson's "Chemical Analysis of Special Steels," also Lord & Demorest's "Metallurgical Analysis."

Non-Ferrous Alloys

The number of different methods of analysis used in non-ferrous alloy work is so great that it would be practically impossible to deal with them comprehensively in this paper. The author uses electrolytic methods for determining copper, lead and zinc in brass and bronze where the lead does not exceed 10 per cent. If the alloy contains more than 10 per cent, the lead is determined as $PbSO_4$. Some means of agitating the solutions when electrolysis is in progress will aid in obtaining quick results. Rotating anodes or cathodes may be used for this purpose, also solenoids, or even compressed air. Where allowable, much time can often be saved by taking some element by difference after all other elements present have been carefully determined. It is perfectly legitimate and accurate, providing the other figures are correct. Whenever determined in this way the fact should be noted in reporting. For instance, in the analysis of Muntz metal, copper, lead and iron may be determined accurately in a very short time. Tin or any other impurities may also be tested for or actually determined quickly. After this is done there is no reason whatever why zinc should not be reported as the remainder, unless for some reason the practice is not allowed. The practice is a dangerous one if not carried out in a conscientious manner. It is never done in this laboratory except with the full knowledge and consent of the client, as some object for reasons best known to themselves. The majority, however, prefer to have it done this way where speed is a factor.

The white metal alloys cover a very large field and include babbitt metals, solders and aluminum alloys. Various types of babbitt metals require different procedures. For instance, tin-base babbitts must be handled in a different way than lead-base babbitts, while those alloys containing more antimony than tin act differently than those in which tin predominates. In fact, the subject is such a broad one that it would be impossible to do it justice in this article. Chemists who are doing this sort of work should always bear in mind the point made above regarding the possibility of using shorter methods of procedure. Get in touch with your fellow chemists and find out what methods they are using. Search the literature also, keeping in touch with the current information. If someone publishes a method which looks reasonable and seems shorter, do not be afraid to try it. If it gives satisfactory results after a thorough trial, adopt it. Many methods with excellent possibilities are condemned after one trial, often when it is not the fault of the method itself, but because the operator had not learned how to handle it properly. Many chemists are using long procedures which have been handed down to them simply because they give accurate results and because they have not the necessary nerve to find out for themselves if a shorter one will prove to be as accurate. If everyone assumed this attitude there would be no progress.

Planning the Work

Here, too, it is difficult to offer any very specific suggestions on account of differences in conditions such as nature and volume of work, whether or not it can be handled in the routine manner, facilities, etc. The first thing to bear in mind in planning the work in a busy laboratory is that every minute must be utilized to the best advantage. It is customary in many laboratories to divide the analyses between several men who always make the same determinations. This seems to be the most efficient way of handling it, and wherever possible it is preferable.

The author has found that it works well to weigh all samples for the day's work at one sitting and to start

them all off as quickly as possible. Those determinations which will need no attention for some time should be started first and others which require considerable attention can be worked in. Moreover, if there are several miscellaneous samples upon which similar determinations are required, these should all be run along together, or at least as many as facilities will allow. It will often prove to be a saving of time to sit down at the beginning of the day and to spend a few minutes merely making plans for the day's work. It will not always be possible to adhere strictly to these plans, but it will help considerably.

There are many ways of saving time in the common manipulations which it may seem superfluous to mention. Still, they are important from the standpoint of speed, and not all chemists make use of them. It is only for such analysts that the suggestions are intended.

There is the question of filtering. One of the first things a chemist usually learns in a laboratory or in college is how to choose a good funnel and how to fit a filter paper into this funnel properly. In spite of this it is surprising how many are careless in this respect and do not seem to realize how much unnecessary time may be lost by slow filtrations. It is not the intention to describe how this should be done, as it is too well known, but merely to call attention to the importance of painstaking in this direction. It is sufficient to say that the filter paper should fit perfectly. Long straight-stemmed 60 deg. funnels work best. They will be found to filter faster if the angle formed by the stem and funnel proper is abrupt, rather than flaring.

The grade of filter paper is also important. A paper of no closer texture should be used than is necessary to hold the precipitate which is being filtered. If possible, a column of liquid should be maintained in the stem of the funnel. This may be done either by gentle pressure on the mouth of the funnel with the palm of the hand or by playing a strong stream from the wash bottle around the upper edge of the filter paper. Many slow-filtering precipitates, such as aluminium hydrate, may be filtered and completely washed in two to three minutes by using suction and a Buchner funnel. It will be found a great time saver in weighing, instead of having the balance adjusted to zero to have it so adjusted that the pointer will swing three divisions to the right. This saves waiting for a swing in both directions. It is obviously necessary to have it swing the same distance before and after the weight.

The use of factor weights in gravimetric work saves considerable time in calculations. In weighing steel samples a magnetized spatula may be used to good advantage in the final adjustment. It will also be of value in steel work to bear in mind the fact that it is a waste of time to attempt to weigh samples for those elements such as sulphur, phosphorus, silicon etc. which are present in small quantities with the degree of accuracy necessary with higher percentages. Much time, also confusion, may be saved by always forming the habit of arranging numbers in order when filtering etc., the lowest number always at the left, or right, as the operator prefers.

Conclusions

It is realized that many of the suggestions which have been offered will seem too obvious to many to warrant publication. On the other hand, if a solitary chemist is assisted by anything which has been offered, the paper will be justified. The valuable assistance that can be obtained by keeping constantly in touch with one's fellow workers and by making occasional visits to other laboratories cannot be overestimated. Do not be afraid to admit that someone is doing something in a way of which you have never heard. By doing so you may create a barrier between yourself and valuable information. Do not lose sight of the fact that your knowledge, as well as that of everyone else, is limited; admit it by asking questions. The other fellow will think more of you and tell you more.

Arthur D. Little, Inc.,
Cambridge, Mass.

A New Method of Microscope Illumination

(*Second Paper*)

By Alexander Silverman

In a number of papers[1] which have appeared during the past year the writer described a new illuminator for microscopes.[2] The supplementary material here given is presented for the benefit of those already using the device and for others who may be interested.

The Lamp.—A new 9-volt, 0.7-ampere daylight (blue glass) lamp has been devised, which will yield 50 per cent more light than the old 6-volt, 0.7-ampere lamp. The illumination is not only better but the terminals of the lamp are closer together so that the filament more nearly approaches a complete circle. Researches which are under way may provide a lamp of still greater light intensity. A new enamel is employed for the reflector to prevent the scaling experienced with the old type.

The Rheostat.—A tube resistance with three connecting-posts for 107 v., 112 v., and 118 v. permits of the use of the lamp with the ordinary A.C. or D.C. lighting circuit. A similar device for 220-v. circuits is in preparation. By connectting on a lower voltage tap the light may be increased for photographic purposes.

Heat Insulation.—Although the writer has had the illuminator attached to objectives and going constantly for a half hour at a time, no injury was suffered by the objectives. The circular space of about one-quarter of an inch between the holder and the objective permits cold air to circulate between the two. Although the heat radiated and conducted should not prove serious, an effort is being made to lower the temperature of the lamp by reducing the size of the anchor wires. Radiated heat may be cut down by giving the lamp a black coat over the white enamel reflector.

The Shutter.—A shutter has been devised which may be slipped into the holder for cutting off the light from one-half of the field. The shutter may be revolved so as to send oblique light from any side to the specimen under examination. This is of value in detecting pearlitic structure in iron, etc.

Vertical and Oblique Light.—The new illuminator may be attached to the microscope without removing the

[1] *J. Ind, Eng. Chem.*, 9971 (1917). *Met. & Chem. Eng.*, 18,318 (1918).

[2] U. S. Pat. 1,267,287. Can. Pat. 185,283. Other U. S. and foreign patents pending.

vertical illuminator, thus affording a rapid comparison of the effect of vertical and oblique light. Details may be visible under one illuminator which would not appear with the other. For example the interior of small pores and slag pits is usually black under vertical light, while the new illuminator shows depth and the nature of the content if slag or other substances are present.

Photomicrography.—Some metallographers are still skeptical because of the low power of the lamp, as they have been accustomed to using arc lamps or powerful nitrogen-filled tungsten lamps.

As has been intimated in earlier papers, definition in ordinary photography is obtained by using a very small aperture and giving a long exposure. The writer's experience has been that excellent photomicrographs are obtainable with the new lamp in a few minutes by removing the eye-piece and that with 8-mm., 16-mm., and objectives of lower power, even 60-mm., clear images are obtained on the ground glass. Even better results may be obtained using a very fine etched ground glass and rubbing the dull surface with a little vaseline, afterwards removing as much of it as possible with a dry cloth. Fine definition is possible with highly polished steels, brasses, bronzes, etc. Even ball bearings give a clear image on the treated ground glass.

The writer desires to express his appreciation of the valuable suggestions made by numerous scientists who are doing pioneer work in this new field of micro-illumination.

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Electrolytic Refining of Antimony

BY Y. C. WONG

LOW grade antimony ores are not a commercial source of antimony at the present time, although for over thirty years many chemists have from time to time, chiefly under the stimulus of war-time metal prices, patented processes for extracting antimony by means of a cheap solvent and depositing the pure metal electrolytically. That antimony could be electrolysed from alkali antimony polysulphides was reported by Lukon[1] in 1880, Classen[2], and Ludwig[3]. Dr. W. Borchers[4] developed a commercial process at one time used in Germany for extracting with boiling sodium sulphide, which solution was conducted through a series of ten cells, wherein the antimony was all deposited. It was found that the metal was deposited in equal quantity, both from thio-antimonates and thio-antimonites; an excess of sodium sulphide, as was proposed by Classen and Ludwig, or sodium hydroxide was found essential in order to prevent separation of sulphur at the anode, the amount of this addition being such that after the removal of the anitmony there is at least one atom of sodium to every atom of sulphur—in other words, the reaction takes place best when three molecules of sodium sulphide (Na_2S) are present for each molecule of antimony sulphide (Sb_2S_3). Solution such as sodium hydroxide, potassium hydroxide, ammonium sulphide etc. are very satisfactory for laboratory work but not the most economical for commercial purposes. Siemens & Halske (D. R. Pat. 67,973, 1892) and von Engelhardt and Nettel (U. S. Pat. 568,843, 1896) used the alkali earth sulphides and regenerated the solution, thus obtaining a cycle with but small losses. A current density of 0.8 amperes per sq. cm. with a voltage of 0.8 gave 76 per cent efficiency, 0.621 kilograms of antimony being refined per kw.-hr.

[1] *Zeitschrift fur Analytische Chemie.* P. 14. Vol. xix, 1880.
[2] Classen, "Quantitative Analysis Durch Electrolyse."
[3] *Berichte der Deutschen Chemischen Gesellschaft.* P. 1104. Vol. xviii, 1885.
[4] Borchers, "Electrometallurgie."

Laboratory Work

In preparing extraction solutions for test purposes in the laboratory, 27.8 grams of quick-lime and 22.2 grams of flowers of sulphur are mixed in a liter beaker, then covered with 750 cc. of water and the mixture heated on a hot-plate for 45 minutes, stirring continuously to prevent the beaker from cracking. After the cherry-red color has appeared and no more sulphur flowers gather on the surface of the solution it is filtered, cooled, and the filtrate transferred into a bottle and diluted with water to 2 liters. The reaction is as follows:

$$3CaO + 4S = 2CaS + CaS_2O_3$$

In testing some antimonial extracts, several 40 cc. portions were taken, giving on analysis 0.962 grams of antimony, to which were added 15 cc. of calcium sulphide solution (sp. gr. 1.18), gram of sodium chloride, 4 cc. of sodium hydroxide solution (10 per cent) and diluted to 400 cc. with hot water. In commercial work, the diluting liquor would be the wash water used in removing the calcium thio-antimony salts from the extraction tanks. In electrolysing, the cathode used was a plane clyinder of platinum foil, 3 by 8 cm., having an exposed surface of 39.3 sq. cm. and weighing 10.71 grams. A heavy platinum wire about 3½ cm. long was attached to the external circuit. A helix of platinum wire ½ cm. in diameter served as the anode, which was placed within the cathode. With a voltage of 1 to 1.2, and a current of 0.4 amperes, 90 per cent of the antimony was deposited in one hour. As the form of the deposit is not a criterion, greater current density could be used to speed up the process. If too large an excess of sodium hydroxide be present, the antimony will form a black, powdery, non-coherent deposit.

A fair estimate of the cost of refining by this process on an industrial scale based on comparative data from general electro-metallurgical costs would be five cents per pound. As a 36 per cent ore sells at about 88 cents per unit, the antimony would cost 4.4 cents per pound in the ore state. After transportation, brokerage and incidental charges are paid, a profit of 2½ to 3½ cents per pound of refined metal would remain at the present price of 13 cents.

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Lead Prices in New York

Prices for lead at New York from 1914 to 1918 were quoted as follows:

	1914	1915	1916	1917	1918
Jan.	4.11	3.74	5.94	7.56	6.62½
Feb.	4.06	3.82	6.23	8.34	7.14
Mar.	3.97	4.03	6.83	8.98	7.25
April	3.82	4.20	7.50	9.00	7.08½
May	3.90	4.23½	7.50	9.71	7.00
June	3.90	5.87½	7.02	10.81	7.51
July	3.90	5.74	6.54	11.00	8.04
Aug.	3.80	4.75	6.25	10.94½	7.75
Sept.	3.86	4.62	6.75	8.94	8.05
Oct.	3.54	4.59½	7.00	6.84½	
Nov.	3.68	5.15	7.00	6.14½	
Dec.	3.80	5.34½	7.44	6.25	

The American Pyrophoric-Alloy Industry*

Development of the Rare-Earth Industry in Connection with Welsbach Gas Mantles—the Cerium Group By-Products and Their Domestic Production

BY ALCAN HIRSCH

THE pyrophoric-alloy industry is very young, and intimately associated with the rare-earth industry which is also of comparatively recent origin. In order to make the situation clear, it will be necessary briefly to outline the meaning, foundation and history of the rare-earth industry. The term refers to those industries which mine, separate, purify and use the earthy metals or salts of metals formerly considered rare; *i.e.*, gerium, lanthanum, didymium, yttrium, zirconium and thorium. The rare-earth industry was founded in 1885 by an Austrian, Baron Auer von Welsbach, who while investigating certain ores discovered the brilliant light-emitting qualities of their oxides, and invented the incandescent gas mantle. This mantle was made of oxides of lanthanum and zirconium to which a little cerium oxide was added. Welsbach secured patents in various countries, and sold them to investors. About 1887 the industry took root in the United States with the formation of the Welsbach Light Company.

The early gas mantles proved somewhat of a disappointment. Welsbach was in danger of being discredited and pushed his research further, particularly investigating ores of thorium. The early mantles only gave about ten candlepower with a combustion rate per hour of one cubic foot of gas, but the use of thorium salts considerably improved this, and purer and still purer thorium salts were tried until finally they were refined to the extent that they emitted no light at all. To make a long story short, it was found that while thoria should be almost the entire constituent of a mantle, the presence of one or two per cent of other oxides, chiefly that of cerium, was essential to high light-emissive value. This leads us to the present incandescent gas mantle, with which we are indirectly concerned in so far as its production leads to by-products from which pyrophoric alloy is produced.

CERIUM RECOVERED FROM GAS-MANTLE WASTES

The original sources of thoria (thorite) in Norway proved totally insufficient in quantity to supply the demand for gas mantles. The manufacturers, therefore, turned to monazite sand, found rather plentifully in Brazil and India and to some extent in North Carolina, as a source of thoria. About 15 to 30 per cent of monazite sand is phosphoric acid, the bases of which mainly consist of various oxides of the rare earths, 20 to 30 per cent oxide, 20 to 30 per cent oxides of lanthanum and didymium in varying proportions, and small percentages of the yttrium and zirconium oxides. All of these are practically useless in any quantity in the gas-mantle business. It is the 2 to 10 per cent of thorium oxide, averaging about 6 per cent, for which the monazite sand is refined. More than a quarter of a million pounds a year of thorium oxide is produced in the United States from about five million pounds of monazite sand, of which the by-product is mostly wasted. This by-product of so-called "cerium oxides" or "mixed rare-earth metal oxides" amounts to considerably more than a million pounds per annum, and constitutes the raw material for making pyrophoric alloy.

It should here be made clear that what is called "metallic cerium" and used as such, is really a mixture of cerium, lanthanum, didymium, samarium, etc., all very closely allied and very similar metals. It is not necessary to separate them, but the salts for making the metal must be purified. The process for making metallic cerium and the like is described in U. S. Patent 1,273,223, July 23, 1918, to Messrs. Alcan and Marx Hirsch.

The cerium metals are reduced in an electric furnace by electrolyzing their molten salts. The first step is to obtain the electrolyte. We have found that to secure an electrolyte suitable for the continuous commercial production of metallic cerium, certain special precautions are necessary. Certain rather limited ranges of temperature are required for efficiently performing the two processes carried out in the electrolytic cell, and these are called respectively "separating temperature" and "agglomerating temperature." The electrolyte is prepared preferably by using the oxides described above which are the by-product from the incandescent gas-mantle industry. The cerium group oxides are dissolved in commercial hydrochloric acid, reasonably free from sulphuric acid and sulphates, using as little heat as possible, and preferably maintaining an excess of the oxides. The solution consists of a mixture of the chlorides of cerium, lanthanum, didymium, samarium, yttrium, thorium and other rare-earth metals, of which cerium is the chief constituent.

Contrary to common belief, the purity of thi solution is not important except for the percentages of sulphur and phosphorus comopunds on the one hand, and for the bivalent bases such as iron and aluminium compounds on the other, which should each be reduced below 3 per cent. An excess of cerium oxide will precipitate the iron and aluminium, and calcium chloride (or better barium chloride) will throw down the sulphates and phosphates.

PREPARATION OF THE CERIUM SALTS FOR ELETROLYSIS

The solution is then clarified by filtering hot or settling, and evaporated to dryness. The preparation of electrolyte should be so carried out as to secure the proper surface tension conditions between the fused electrolyte and the fused metal when produced in the electrolytic bath. An excess of certain impurities, in-

*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept 27, 1918.

cluding oxychlorides, such as cerium oxychloride, I believe, tends to reduce the surface tension between the metal and electrolyte in the bath and to alter the viscosity, producing an emulsion of colloidal solution of metal in the electrolyte and preventing the separation of the metal from the bath. The oxychlorides may be removed in either of two ways. The chloride solution obtained as above may be evaporated to dryness and then fused in an atmosphere of hydrochloric acid gas to produce complete reduction as well as to prevent oxidation of the electrolyte by the air or dissociated steam. The wet acid gases are condensed hot and dried, and the concentrated hydrochloric acid gas may be used over again. The second and usual method of making the double chloride of sodium and cerium does not yield a desirable bath for electrolysis. If, however, about 15 per cent sodium or potassium chloride (insufficient to make the double salt), and 15 per cent of ammonium chloride by weight, based on the dry weight of the dissolved rare-earth chlorides, are both added before the evaporation to the chlorides after the excess or iron, aluminium, sulphur and phosphorus impurities are removed; the solution may then be evaporated to dryness and dehydration carried through to fusion of the chloride without the production of characteristics resulting in objectionable tension phenomena in the electrolytic bath. The ammonium chloride is dissociated upon fusion and forms a chlorinating agent as does the hydrochloric acid gas in the first method, and may be similarly recovered and used continuously in the process. When the electrolyte formed in this way is subjected to electrolysis, the alkali chloride accumulates in the cell. After the removal of the metallic cerium or "mischmetall," it may be thrown away or dissolved in hydrochloric acid, purified as above explained, and added to the fresh electrolyte.

The Electrolysis of the Cerium Metals

The electrolysis is preferably carried out in pots of cast iron high in carbon and silicon, about 8 in. in diameter and 12 in. to 18 in. in depth, usually set in brick work and externally heated. Heat should be applied almost wholly at the bottom of the pot. It is undesirable to fill the cell as described in the literature. We begin the electrolysis with almost an empty cell, heating a small amount of electrolyte with gas nearly to fusion when the electric current completes the fusion. Thereafter continuing the electrolysis, we gradually add electrolyte, building up the charge in the pot continuously until it is practically full, and a termination of the run is brought about Either carbon or graphite anodes may be used But they each have a critical density; that is, one above which current may pass without deposition of metal For graphite this is about six to seven amperes per square inch of anode surface, and for carbon about five and one-half amperes. Furthermore, we find it desirable to maintain a relation between current density at the anode and cathode, the latter being about one-quarter to one-third of the former, in order to secure a desirable electrical circulating heating effect. By adding solid lumps of electrolyte to the bath, the temperature of the cell is lowered when it becomes too hot. It also contributes a portion at least of the charge required for building up the bath.

As the run approaches 24 to 26 hours in duration, when electrolyte made with the alkali salts is used, the sodium salt accumulates in the charge to such an extent that it becomes advisable to terminate the run. We have found that certain precautions for this termination are necessary in order to secure good yields of cerium. Therefore, preparatory to shutting down the run, we turn on the heating torch full blast, and also increase the current, stirring up the charge in the cell thoroughly about every half hour, for two or three hours. The contents of the cell will be in a very fluid condition if the electrolysis has been properly carried out. The current is shut off, the anode taken out, and the bath moderately and thoroughly stirred for about five minutes, care being taken to cease stirring well before the bath begins to thicken. If iron pots are used, it is most practical to break the pot after cooling to separate the button of metal from the electrolyte.

Preparation of Pyrophoric Alloys

This relatively pure mixed cerium metal or "mischmetall" is soft and does not spark easily on scratching. Consequently, to make pyrophoric alloy it must be made harder, and is alloyed with about 30 per cent of other metals, chiefly iron, to make the commercial sparking metal or pyrophoric alloy which is formed into small pieces to make the "flints" used in lighters, igniters mechanical fuses, etc. The alloy enters into commerce in the form of small strips, rectangular or round, of varying lengths varying from 200 to 2000 pieces per pound. The most general form is a round piece approximately about $\frac{1}{8}$ in. in diameter and $\frac{1}{8}$ in. long, of which there are from 1500 to 2000 pieces to the pound.

The manufacture of these small pieces—the only form in which "mischmetall" is salable—is a most difficult operation requiring what is comparable to equipment for the manufacture of fine jewelry.

The Austrian Pyrophoric Alloy Industry . .

Baron Auer von Welsbach developed the improvement of hardening the relatively soft cerium with iron to make a hard metal which would emit sparks when scratched. He took out patents on this invention the world over. The German and English patents were litigated and held restricted to the use of iron and its equivalent in substantially the 30 per cent named. This is to say, in England the courts held that Welsbach was entitled to protection only on the iron alloys. The United States courts have sustained the patent much more broadly to include and cerium-containing material hardened with any alloyal metal to make the pyrophoric alloy. When Welsbach and his associates developed the pyrophoric-alloy business, they did not form separate companies in each country, but centralized the manufacture of cerium and pyrophoric alloy in the Treibacher Chemische Gesellschaft of Treibach, Austria (a part of the rare-earth cartel or trust). As stated above, they established branches of this Austrian company in England, France, Russia, United States, etc. It was not until some time after the first attack on France by Germany that a pound of cerium was made anywhere in the world outside of the Central Powers so far as I can learn, and then it was made by the New Process Metals Co., which operates under our basic patent on metallic cerium.

Therefore, to reiterate somewhat for the sake of clearness, until the start of the European war the pyrophoric-alloy business of the world was operated as follows: The German and Austrian rare-earth gas-mantle cartel or trust turned over to the Treibacher Chemische Gesellschaft a large part of their cerium residues, which the Treibacher company made into metallic cerium. The Treibacher company exported this metallic cerium to its branches in France, England, United States etc. which branches alloyed the metallic cerium with about 30 per cent of iron and other metals, and cast the alloy into small pieces, selling these pieces to the manufacturers of pocket lighters, miners' lamps, gas lighters, etc. The business of marketing the small pieces of pyrophoric alloy was protected by the patent mentioned which has been contested, and as stated, very broadly sustained in this country.

The American branch of the Treibacher Chemische Gesellschaft was established about 1907, and handled all the pyrophoric-alloy business in this country. After August, 1914, the efficiency of the British Navy made it impossible for the Treibacher company to deliver cerium metal to its agency in the United States. They tried by every means to secure cerium metal from Austria, even trying to import it by the submarine *Deutschland*, but were unsuccessful.

In 1915 the American agency of the Treibacher company got in touch with a chemical company in this country and tried to have this company produce metallic cerium for them. After working several months this company was unable to do so. The president of this company then learned that I had secured my degree from the University of Wisconsin as the result of research on the electrolytic preparation of metallic cerium, and engaged my firm to work out a process for the commercial manufacture of this metal. My brother and other assistants were associated with me in our joint laboratories. After several months of intensive work in the laboratory, metallic cerium was commercially produced of satisfactory quality and in regular quantity. Thereupon the New Process Metals Company was formed which manufactures and sells this material. From that time until April, 1917, the New Process Metals Company furnished metallic cerium to the American branch of the Treibacher Chemische Gesellschaft located in New York City.

The Formation of an American Company

In April, 1917, the manager of the American branch of the Treibacher concern formally notified the New Process Metals Company that he personally, doing business under the name of the American Pyrophor Company, had purchased the business of the Treibacher Chemische Gesellschaft. From April until December, 1917, the New Process Metals Company continued to furnish metallic cerium to the American Pyrophor Company. After war against Austria was declared, the property of the American Pyrophor Company, or the Treibacher Chemische Gessellschaft, whichever you choose to call it, was taken over by the Alien Property Custodian of the United States.

From the foregoing it is seen that the New Process Metals Company developed the cerium business in America. From shortly after the start of the war until the autumn of 1917, it was the only company in the world outside of the Central Powers making metallic cerium, and the pyrophoric alloy made from this product supplied the needs of the armies and civil populations of Russia, France, England, South America, United States, etc. In this connection, it is interesting to note that the cerium lighters have been extensively used in the trenches, first because of the great scarcity of matches in Europe, and second because of the effect of dampness on matches. We are glad to be able to say that for several years prior to 1918 we supplied the British and French Armies with their requirements of pyrophoric alloy. Now this metal, we understand, is being made in France.

The future of the pyrophoric-metal business in this country is an interesting field for speculation. We hope to be able to maintain it to some degree at least. Frankly, it is our potential ability to market our alloy in the form of lighters upon which we rely for the continuance of our company, and we anticipate that our lighter manufacturing facilities will become so developed and economical as to enable us to meet Austrian competition successfully after the war.

Speeding Up the Steel Works Laboratory

By H. C. Kimber

IN THESE strenuous times it falls to the lot of many to remain at home to produce the materials necessary to the continuance of warfare. It is imperative that every bit of energy and every minute be conserved in order that the army and navy may receive the best material that it is possible to make in minimum time.

The following suggestions and methods of analysis have proved of great value in the production of electric steel. A ¼-inch flat high-speed drill produces excellent drillings for weighing, as they are practically free from the curls produced by the twist drill. There is a natural tendency for the chemist to spend too much time weighing out the samples. The degree of accuracy necessary may easily be calculated. For example, it is not necessary to weigh a five-gram sample for sulphur as accurately as a two-tenths gram sample for manganese.

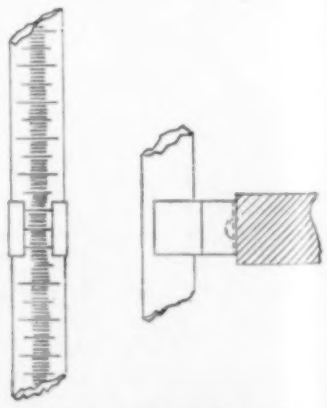


FIG. 1.—BURETTE CLIPS

Automatic overflow burettes and pipettes are convenient and almost indispensable in small laboratories having a large amount of work to be done each day. With these burettes and pipettes large quantities of standard solutions may be made up at one time and economically used. A suggestion for the titration bench is shown in Fig. 1. The clips which hold the burette in place are fuse clips used to hold 220-volt fuses. The burette is rigid and every graduation is visible.

An excellent routine method for the determination of carbon in steel is outlined below.

The Train Before the Combustion

The apparatus, shown in Fig. 2, consists of a calcium chloride tower *B* filled with sticks of sodium hydroxide, or half filled with calcium chloride, and half with soda lime, the former on top; a twelve-inch tube *E* made of $\frac{3}{16}$-inch glass tubing, a Y-tube *D*, an equalizer *C*, and a stop-cock *F*. Immediately after the combustion apparatus *G* there is connected to the combination tube an orifice *H* which regulates the flow of oxygen through the train.

The tower *B* containing the sodium hydroxide or soda-lime is connected directly to the oxygen gage *A* and

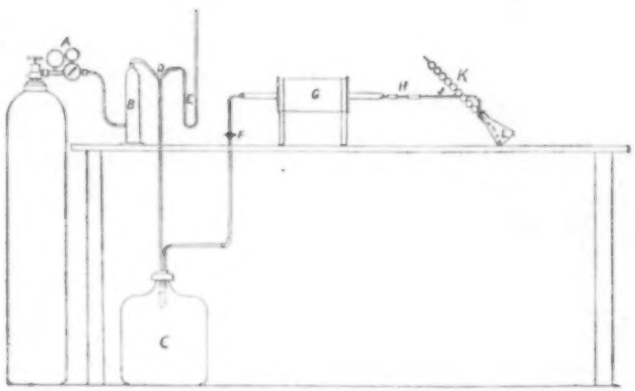


FIG. 2.—APPARATUS FOR DETERMINATION OF CARBON

Y-tube *D* as shown. The U-tube, which is connected to one leg of the Y-tube, contains enough mercury to fill it four inches deep. The third leg of the Y-tube leads into the equalizer, which must be clean and dry. A delivery tube terminating with a stop-cock *F* of either glass or brass, leads to each combustion furnace and train (only one is shown in the illustration). The equalizer may be a five-gallon bottle or any convenient gas-tight container. If a bottle is used the rubber stopper must be wired in. All connections must be made with high-pressure tubing.

After all the connections are made the stop-cock is shut and the oxygen is let into the apparatus until the difference in the level of the mercury in the U-tube is six inches. This serves as a pressure gage. The cock may then be opened, and the gas allowed to escape until it is reasonably certain that all the air has been replaced by oxygen. The apparatus may then be tested for leaks.

Combustion Apparatus

There are a number of good electric furnaces for laboratory use giving a temperature of from 950 to 1100 deg. C. Combustion tubes of quartz or clay are in common use and may be obtained to fit the bore of the furnace.

Boats made of porcelain, quartz, alundum, clay or nickel may be used, but in any case the boat should be lined with a protecting layer of "RR" alundum, alkali free, specially prepared for carbon determination.

A plug of loosely packed asbestos fiber is placed in the outlet end of the combustion tube, together with a catalyzer of either copper oxide, platinized asbestos or platinum gauze. Some authorities maintain that a catalyzer is unnecessary, but its use gives a certain factor of safety. A temperature of about 1000 deg. is the best when no flux is used.

The Train After the Combustion Apparatus

This consists of an orifice *H*, a delivery tube *J*, a 500-cc. Erlenmeyer flask *L* and a Meyer bulb *K* of special design. The bulb is about 45 deg. from the horizontal. A rack may easily be built for this purpose.

The orifice is made by heating the end of a piece of fairly heavy-walled glass tubing, with constant rolling, until it is nearly sealed. This makes a very small hole which lets the oxygen through at the desired speed. The time between turning on the oxygen and the instant the bubbling begins through the absorbtion bulb should be about twenty seconds. In other words it should take twenty seconds for the bulb to fill with the barium hydroxide. Following a little practice, the operator should have very little trouble in making these. It is necessary to put a filter of some sort (either a wad of cotton or asbestos) in front of the orifice to catch any ferric oxide which volitalizes while the steel is burning.

The great advantages of this apparatus are that it requires little attention. It is almost impossible for incomplete combustion to ensue due to insufficient supply of oxygen and because of this no difficulty is experienced in burning the sample without a flux at 1000 deg. C. All samples are tested under identical conditions, as the oxygen is always present and at a constant pressure.

Solutions Required

Barium Hydroxide.—Dissolve 300 g. of barium hydroxide in 3 liters of hot freshly distilled water. (Put 100 g. in a liter flash or beaker and shake or stir frequently until solution is complete, except for a little precipitate of $BaCO_3$ which is sure to form). Make this solution up to 19 liters with freshly distilled water in a 5-gallon bottle. After mixing thoroughly allow this solution to stand for at least 24 hours before using.

Hydrochloric Acid.—Dilute 151 cc. of concentrated hydrochloric acid to 19 liters with distilled water.

Phenolphthalein Indicator.—Dissolve 2 g. of phenolphthalein in 1000 cc. of alcohol.

Accessory Apparatus

It is quite essential to have exactly the same volume of barium hydroxide for each determination. The best means of obtaining this is with an automatic overflow pipette of 80 cc. capacity. A 100-cc. automatic overflow burette may be used for the hydrochloric acid. The phenolthphalein solution is best introduced into the flask containing the barium hydroxide by means of a dropping bottle.

A very convenient way to wash the Meyer bulb is by means of a wash bottle, fitted with a syphon tube and clamp placed on a shelf over the train.

As it is desired to run the oxygen through the train for eight minutes, an eight-minute sand glass or any timing device will prove convenient.

A direct-reading scale is also convenient and may be made by determining the number of cc. for a two per cent carbon steel and measuring this distance on the burette. A draftsman can easily make a scale from these data so that every line will read to a hundredth per cent carbon when the zero or bottom of the scale is at the blank reading. This scale, drawn on a narrow strip of paper and inserted in a glass tube, may be fastened to the burette and adjusted at will by means of rubber bands.

The zero point is placed opposite the blank reading and the percentage carbon may then be read directly from zero up to 2 per cent carbon when a one-grain sample is used.

Operation of Train

Draw out 80 cc. of barium hydroxide into a 500-cc. Erlenmeyer flask. Connect this flask to the Meyer bulb immediately. The end of the Meyer bulb tube should reach to the bottom of the solution.

A blank is first run to determine the zero reading. After the flask containing the barium hydroxide is in place the train is connected by placing the stopper in the silica tube. The oxygen is then turned on and allowed to run for eight minutes. At the expiration of this time the oxygen is turned off, the Meyer bulb rinsed out with distilled water from the overhead wash bottle, and the end of the bulb and the sides of the flask washed. Five or six drops of phenolthphalein are added and the solution titrated to a faint pink with the standard hydrochloric acid which has been prepared as described.

If the solutions have been properly made, 80 cc. of barium hydroxide will be equal to about 85 to 86 cc. of the standard hydrochloric acid.

This reading is the zero point for the carbon determination. A standard steel from the U. S. Bureau of Standards, or its standard equivalent, must then be run to determine the factor. The blank reading minus the reading obtained by running the standard steel times 0.06 gives the percentage carbon in the steel if solutions are correct.

Notes

The interval from the time the oxygen is turned on until the instant the bubbling begins through the Meyer bulb is about 25 seconds. This is controlled by the size of the orifice.

The barium hydroxide solution should be prepared as quickly as possible to minimize the precipitation of barium carbonate due to contact with the atmosphere. A guard tube containing soda-lime must be connected to the tube through which the air is admitted into the bottle of barium hydroxide to free the air from CO_2.

In titrating the barium hydroxide with the hydrochloric acid the flask containing the solution must be agitated continuously to prevent an excess of hydrochloric acid in one spot. If this is not done the hydrochloric acid will react with the precipitated barium carbonate and the results will be incorrect.

Blanks and standard steels should be run at least once every 24 hours, as solutions change slightly.

The description refers to only one train, but a number of trains may be attached to the equalizer and arranged according to the room available.

Determination of Chromium in High-Speed Steel

The following method for the determination of chromium in high-speed steel is simple and accurate.

Solutions

Sulphuric acid, sp.gr. 1.84, 1:3.

Microcosmic salt, 15 per cent solution is distilled water.

Nitric acid, sp.gr. 1.42.

Silver nitrate. Dissolve 5.28 grams of silver nitrate in 2 liters of distilled water.

Ammonium persulphate. Dissolve one pound of ammonium persulphate in 2400 cc. of distilled water.

Hydrochloric acid, sp.gr. 1.20, a 5-per cent solution.

Standard ferrous ammonium sulphate. Dissolve 57 grams of ferrous ammonium sulphate in 3000 cc. of distilled water and add 100 cc. of sulphuric acid sp.gr. 1.84.

Standard potassium permanganate. Dissolve 3.66 grams of potassium permanganate in 2 liter of distilled water.

Method

Dissolve one gram of the sample in 50 cc. of sulphuric acid (1:3) and add 40 cc. of 15 per cent microcosmic salt. When the steel is completely in solution, add 20 cc. of nitric acid, sp.gr. 1.42, and boil until free from brown fumes. To this solution add 50 cc. of the silver nitrate solution and 50 cc. of the ammonium persulphate solution and boil until the small bubbles of oxygen cease to be evolved; then add 15 cc. of 5-per cent hydrochloric acid and boil until the last trace of the permanganate pink is gone and then remove the flask to the cooling bath.

To the cold solution add 25 or 50 cc. of the standard ferrous ammonium sulphate, depending on the chromium content of the steel, and titrate the excess with the standard potassium permanganate to a permanent pink. A blank and a standard steel must first be run. Blank minus the titration multiplied by 0.1 equals the percentage chromium if the solutions are correct; if not, they must either be corrected or the factor established.

Notes

Upon adding the nitric acid the tungsten present is converted to the soluble phosphotungstic acid.

As vanadium reoxidizes rather slowly, it is advisable to wait for at least 30 seconds to be certain that the correct end-point has been reached.

A 25-cc. automatic overflow pipette is best for measuring the standard ferrous ammonium sulphate.

It is advisable to keep the standard ferrous ammonium sulphate solution in the dark under the titration bench, and pump it into the pipette with a rubber bulb. The rubber tubing will also last longer under these conditions. A blank and a standard steel should be run every other day.

John A. Crowley Co., Detroit, Mich.

Ferro Alloys in Japan

Before the war all iron alloys, except a certain amount of ferromanganese, were imported from abroad; but lately a great many plants have been established for the preparation of many kinds of iron alloys. Ferro silicon, ferro chrome, ferro tungsten and ferro molybdenum are most important for the preparation of special steels. The following table shows the amount of such alloys formerly imported.

IMPORTS OF FERROUS ALLOYS

	1913 Tons	1914 Tons	1915 Tons
Ferro silicon and silicospiegeleisen...	1,900	1,220	1,710
	$84,800	$85,400	$123,870
Ferro manganese	4,500	1,200	2,950
	$257,000	$65,000	$212,000
Spiegeleisen	2,000	725	640
	$54,000	$22,000	$22,000
Ferro chrome and all other non-malleable alloys	750	225	1,200
	$115,000	$43,000	$160,000

Radioactive Luminous Materials

Sequence of Scientific Development of Research on Radioactivity Phenomena—Recent Technical Uses of Radium Luminous Materials—Adaption to War Needs

By WALLACE SAVAGE

IN THE middle of the last century physicists were very much interested in the luminous phenomena produced upon the passage of electric sparks through rarefied gases. The gases were ordinarily enclosed in glass tubes into which platinum wire electrodes were fused at proper places. The Geissler tube was one of the simplest, being a straight tube bulbed at the center and cathode end and having a vacuum of a few millimeters of mercury. Upon the application of sufficient electromotive force, the discharge electrode (cathode) became surrounded by a mellow, deep-blue, luminous envelop, called the "glow-light." From the positive electrode (anode), a peach-red tongue of light extended almost through the entire tube. That these flames were negatively and positively electrically charged air particles was established by their being deflected by the respective poles of the magnet and by their mechanical properties—a small experimentally interposed wheel with mica paddles being rotated by the impact of the

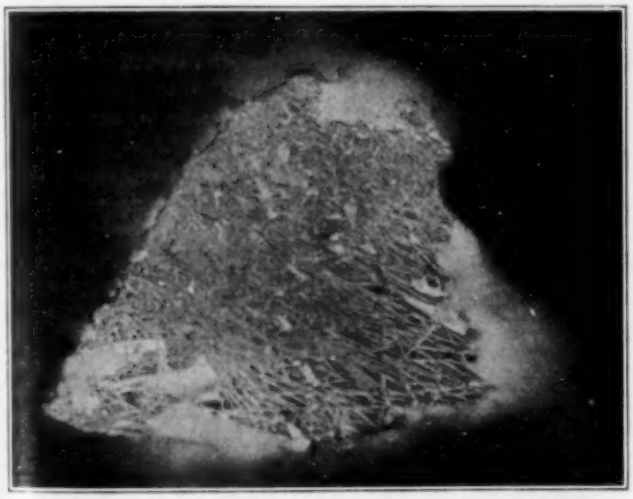


FIG. 1. RADIO-PHOTOGRAPH OF FERRO-URANIUM
Courtesy, Standard Alloys Co.

stream. Upon absolute exhaustion of the tubes, no current was conducted, which verified further the mechanical nature of the phenomena.

In 1895, Roentgen surrounded one of these types of exhaused tubes (Hittorf's) with black light-opaque cardboard, and discovered that a fluorescent substance (barium-platino-cyanide) was made luminescent when current passed through the covered tube. To his astonishment he found that there were being emitted rays similar to light excepting in that only metals and mineral substances prevented their passage. He had discovered the X-ray, which was to become one of the greatest appliances in the practice of surgery. In subsequent investigations, it was established that the X-ray was produced at the glass wall of the tube by the impact of the arrested negatively charged air particles, which set up a high frequency vibration in the glass wall, which in turn effected the light bearing medium.

Discovery of Radioactivity of Uranium

While following out Roentgen's X-ray discovery in its connection with the phenomenon of fluorescence and phosphorescence, Henri Becquerel made an as yet un-

FIG. 2. RADIO-PHOTOGRAPH OF URANIUM STEEL

foreseen and equally important discovery—radioactivity in uranium. His custom was to expose a fluorescent substance to light action, then to register the lag of the glow by its effect on photographic plates protected from ordinary light. Exposed uranium acted on the plates and Becquerel believed he had established a relation between fluorescence and X-rays. Later he exposed a plate to uranium that had not been recently acted on by light. To his surprise, upon developing the plate, he found that he obtained the same effect as with the light activated uranium. Some permanent actinic effect was indicated. Fig. 1 is a photograph of ferro-uranium (U, 35.4 per cent) taken by its own light with 112 hours of exposure. The light portions indicate the richer uranium crystals. In Fig. 2, the effect of dilution can be seen, the sample being uranium steel (U, 7.74 per cent) photographed with the exclusion of all foreign light.

Mme. Curie, wife of the professor of physics of the Sorbonne, Paris, took up the radioactive investigation. In searching for other examples, she found that thorium exhibited similar phenomena, which were proportional to atomic properties. A given weight of uranium metal had the same activity, no matter whether it was combined as a chloride, bromide, sulphate or nitrate, foreign elements exhibiting no influence upon the activity. She then investigated pitchblende, from St. Joachimsthal, which is a natural uranium oxide with many other metals in association. Contrary to her expectations

from prior work, the radioactivity of this Austrian mineral was four times stronger than would be expected from its uranium content. This contradicted her conclusion as to the atomic relations of this phenomena and indicated that there must be some other associated element present that until now had not been identified.

The mineral was dissolved and the different groups of elements successively precipitated, each residue being tested for radioactivity. The lead group showed a noticeable actinic effect, which has been identified and termed radium G, radioactive lead (at. wt. 206).[1] The copper group was found to contain a member which

FIG. 3. QUARTZ EVAPORATING DISH WITH 0.007 OZ. OF RADIUM EXTRACT FROM 65 TONS OF URANIUM ORE

Mme. Curie named polonium. Actinium came down with the iron group. The essential part of the activity however was found in the alkaline earth group. Upon making the usual sulphate of barium separation, the activity was located entirely in this residue, the radioactive substance being apparently occluded by the barium sulphate. The latter was reduced with carbon in a retort, and the sulphide dissolved in muriatic acid. The radioactive element was further segregated by fractional acid crystallization, its bromine and chlorine salts being more insoluble than those of barium. The element, radium, was finally obtained pure enough to be thorcughly studied. Fig. 3 shows a quartz evaporating dish containing 200 milligrams (valued at $24,000) of radium salts, which not only furnishes light for registering its own photograph but illuminates the label.

The Nature of Radioactivity

Besides affecting the photographic plate through ordinarily opaque substances, radium ionizes gases—charges them with positive and negative electricity. Three physical phenomena have been identified and termed alpha, beta and gamma rays, of which the latter only is an actual ray. The alpha ray is a positively charged helium particle which is emitted meteor-like from the radium with a velocity of 20,000 miles per second. The beta ray consists of negatively charged electrons, having a mass of $\frac{1}{6400}$ of that of helium and a velocity approaching that of light—100,000 to 186,000 miles per second. The alpha particle is stopped by impact with an ordinary sheet of writing paper, while the beta particle is only arrested by metals. All evidence indicates that the beta particle is similar in its properties to the electron found in the X-ray tube, the cathode ray.

The gamma rays are not material in character but are vibrations in the ether. They are produced upon the impact of the beta particles on matter by the subsequent induced vibration which is transmitted to the ether. The elimination of the alpha and beta particles resembles an explosion within the radium. It has been determined that in 1700 years, radium will be half consumed in this disintegration phenomenon.

The greatest scientific interest has been aroused by the establishment of the fact that this disintegration radioactive phenomenon is actually a case of the transmutation of chemical elements. Table I gives the uranium to lead series[2] and Table II, the thorium to lead. The changes in atomic weight will be noted to be four, the mass of the helium X-ray atom removed.

TABLE I—THE URANIUM RADIOACTIVE SERIES

Series	Half-Value Period	Rays	Atomic Weight
Uranium I	5×10^{9} years	α	238
Uranium X_1	24.6 days	β	234
Uranium X_2	1.15 min.	$\beta\gamma$	234
Uranium 2	2×10^{6} years	α	234
Ionium	10^{5} years	α	230
Radium	1690 years	$\alpha\beta$	226
Radium emanation	3.86 min.	α	222
Radium A	3 min.	α	218
Radium B	26.8 min.	$\beta\gamma$	214
Radium C	19.5 min.	$\alpha\beta\gamma$	214
Radium D	16.5 years	$\beta\gamma$	210
Radium E	5 days	β	210
Radium F	136 days	α	210
Radium G (lead)	.....	...	206

TABLE II—THE THORIUM RADIOACTIVE SERIES

Series	Half Period	Rays	Atomic Weight
Thorium	1.5×10^{10} years	α	232
Mesothorium 1	5.5 years	β	228
Mesothorium 2	6.2 hours	$\beta\gamma$	228
Radiothorium	2 years	α	228
Thorium X	3.65 days	α	224
Thorium emanation	54. sec.	α	220
Thorium A	1/7 sec.	α	216
Thorium B	10.6 hour	$\beta\gamma$	212
Thorium C	1 hour	$\alpha\beta$	212
Thorium D_1	3.1 min.	$\beta\gamma$	208
Thorium D_2 (lead)	10^{3} years	β	208

The Alpha Particle Luminosity

If radium salts are mixed with phosphorescent zinc sulphide, a permanently luminous yellow-colored material is obtained, the light of which is proportional to the radium content. It is found that the impinging of the alpha particles, which are individually visible under the microscope, sets up a vibration in the zinc salt which produces a glowing light. To withstand the perpetual bombardment of these 20,000-mile per second particles, especially strong crystals of zinc sulphide must be obtained.

These are manufactured by sublimation from an electric furnace, the zinc sulphide vapors are condensed in cooling chambers in a fine flour, similar to sulphur. The luminous paint usually carries from 10 to 25 mg. of radium element per 100 gms, depending upon whether a legible contrast glow is needed at the transition periods of day and night—however, too high a radium content is not desirable, on account of the inability of the zinc sulphide crystals to permanently withstand very concentarated impact shocks from the α-ray without deteriorating.

[1] Prof. T. W. Richards, *Jour.* A. C. S., Vol. 36, 1229 (1914); Vol. 38, 221, 1658, 2613 (1916); Vol. 39, 53 (1917); Vol. 40, 1403 (1908).

[2] Richard B. Moore, *Trans.* American Ins. of Mining Eng. No. 140, p. 1169.

Luminous Varnish

Since the war, the Radium Co. of Colorado has established the Cold Light Mfg. Co. at 558 W. 158th St., New York. This latter company has equipped over half a million Marvelite dials on instruments now being used by our military forces. Fig. 4 illustrates an aëroplane altimeter as it appears in the day and night

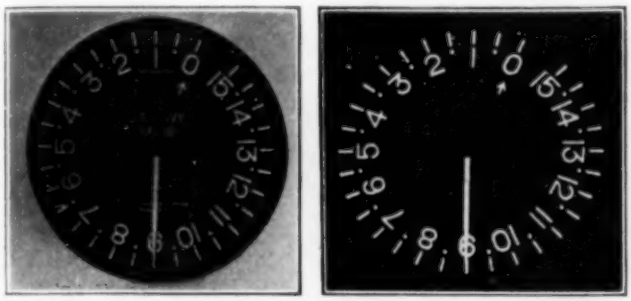
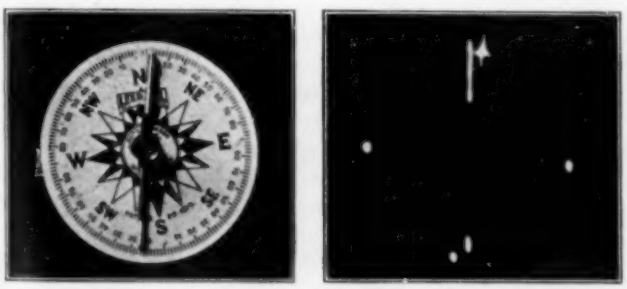


FIG. 4.—ALTIMETER DIAL, DAY AND NIGHT

when 9000 ft. above sea level. Fig. 5 shows a compass, clock and air speedometer. The extent of the military use of illuminated indicating devices may be surmised when upon examining an aëroplane, nine instruments are found so equipped. The civil engineers have found it an exceptional boon, for the spirit bubbles on their levels and transits and the marks on their tapes are made sufficiently visible for them to attend to their



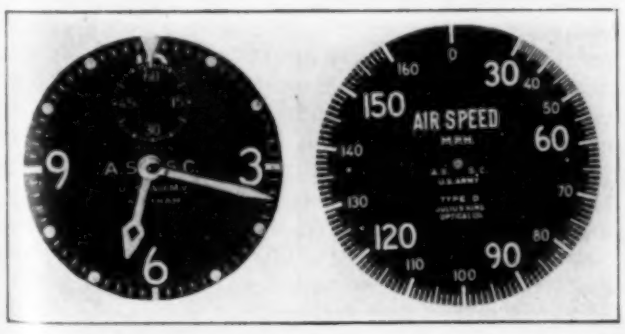


FIG. 5.—MILITARY COMPASS DIAL, DAY AND NIGHT. BELOW, AEROPLANE CLOCK AND SPEEDOMETER DIALS

surveys at night as well as in the day without raising any objection from the enemy. Gun sights are greatly aided by being touched up and night aiming is thus quickly accomplished, when a sudden flare exposes an enemy target.

On the sea, now that lights have to be extinguished because of the U-boats, the pilot has compass, log and all, self-illuminated. Radioactive celluloid sheets are now being manufactured from which FIRE ESCAPE, EXIT, electric push button indicators etc. are stamped. No doubt many valuable applications will be found in engineering practice for this material as distinctive as the uses in "Hunotherapy."

Radium Substitute

Mesothorium is also being used for luminating zinc sulphide. Its half period as will be seen from comparing Tables I and II is much shorter than that of radium; however, for temporary dials on inexpensive watches, clocks etc. which are not expected to last longer than four or five years, its use is fully satisfactory. Mesothorium can also be used in cancertherapy.

Enemy Technical Periodicals Available

Following the passage of the Trading-with-the-Enemy Act, the enemy publications committee of the American Library Association was granted a license by the War Trade Board, whereby universities, colleges, and public bodies of approved character might secure enemy publications of importance to research in science and scholarship, provided the Department of State approved the method and the Censorship Board sanctioned the admission of such material. Two hundred and fifty-five magazines have been approved by these bodies, and approved institutions may enter subscriptions for any of them through the secretary of the committee of the American Library Association, M. L. Raney, Johns Hopkins University, Baltimore, Md. The list of periodicals of interest to technical men here given is abstracted from the report of the committee:

CHEMISTRY

Annalen der Chemie.
Chemisches Zentralblatt.
Deutsche chemische Gesellschraft, Berichte.
Journal für praktische Chemie.
Kolloid-Zeitschrift.
Zeitschrift für analytische Chemie.
Zeitschrift für angewandte Chemie.
Zeitschrift für anorganische und allgemeine Chemie.
Zeitschrift für physikalische Chemie.

TECHNOLOGY

Archiv. für Eisenbahnwesen.
Archiv. für Elektrotechnik.
Armierter Beton.
Beton und Eisen.
Die chemische Industrie.
Deutsche Bauzeitung.
Dingler's polytechnisches Journal.
Elektrotechnik und Maschinenbau.
Elektrotechnische Zeitschrift.
Ferrum.
Gesundheits-Ingenieur.
Glückauf.
Journal für Gasbeleuchtung.
Metall und Erz.
Der Oelmotor.
Prometheus. Illustrierte Wochenschrift über die fortschritte in Gewerbe, Industrie und Wissenschaft.
Rauch und Staub, Zeitschrift für ihre Bekämpfung
Stahl und Eisen.
Verein deutscher Ingenieure, Zeitschrift.
Zeitschrift für Architektur- und Ingenieurwesen.
Zeitschrift für Bauwesen.
Zeitschrift für das ges. Turbinwesen.
Zeitschrift für Elektrochemie.
Zeitschrift für Instrumentenkunde.
Zeitschrift für komprimierte und flüssige Gäse.
Zeitschrift für Transportwesen.
Zeitschrift für wissenschaftliche Photographie.
Zentralblatt der Bauverwaltung.

It is impossible to secure these publications through any other source than that above indicated.

Metallography and the War

By Zay Jeffries

CIVILIZATION is a human product. The utilization of the forces and materials of nature by man has brought about our modern industrial civilization. This has made possible the magnitude and intensity of the present war.

Just as metal has been one of the most important materials—historians pronounce it the most important—used by man in the evolution of our industrial civilization, it is also one of the most important materials used in modern warfare.

Metallography is the "sience of metals" according to the Century Dictionary. Previously the term was used to apply only to the microscopic examination of metals, but in later years its scope has been extended to include the constitution of alloys, heat treatment, deformation, and the study of the properties of metals. The physicist or other scientist may perfect apparatus to measure hardness, high temperature, coefficient of expansion, electric and heat conductivity, or to study the positions of the atoms in a crystal, but when used to determine properties of metals for the purpose of producing uniform metal product, these become, like the microscope, tools of the metallographist.

Production of Metals for Specific Uses

The object in producing a metal or alloy is to fit it for use; its properties determine the utility. Metals require different properties in accordance with their use. For example, in a thermostat the chief property may be coefficient of expansion; in a thermo-couple, melting point or thermo-electric force; in a watch spring, resiliency; in an electric transmission wire, high electric conductivity; in a cutting tool, hardness; in a cannon, high strength coupled with resistance to shock; in an airplane part, high strength, coupled with low specific gravity; in acid vats, non-corrodibility; in armor plate, resistance to penetration, etc. For any purpose the metal having the desired properties and costing the least, should be used.

In the production of metals for specific uses, metallography plays two rôles:

1. The control of the manufacturing processes to obtain uniform products;

2. The development of new alloys or processes to serve specific purposes.

Metal parts used in machines and devices such as airplanes, automobiles, engines, cannon, shells etc. must be dependable. To be dependable the product must be uniform. It is much better to use a metal with an average tensile strength of 55,000 pounds per square inch with minimum and maximum 50,000 and 60,000 pounds per square inch respectively, than to use one with an average tensile strength of 75,000 pounds per square inch, but with minimum and maximum 40,000 and 110,000 pounds per square inch, respectively. Engineers must design with the minimum and not the average values in mind.

It is probably safe to state that owing to the pressing need for quantity production, the principal value of metallography in the production of war materials is in the control of processes which tend to make the products uniform. Of course uniformly good results are better than uniformly poor results so it is to be assumed that the former is the goal. In the study and control of factors leading to the production of uniform product, the metallographist has many tools. The function of each tool is to enable one to determine some specific property of the material which will enable him to predetermine, at least to a certain extent, the utility of the metal part. This predetermination depends on the interpretation of laboratory tests in the light of past experience, the record of performance in use serving always as the absolute guide.

Importance and Limitations of the Microscope

Of all of the places of apparatus used by the metallographist, the microscope is probably the most useful and at the same time the least satisfactory. It is the most useful because we owe to it our knowledge of the "proximate" composition of alloys and of the crystalline structure of single component metals. It is the least satisfactory because the examinations are largely qualitative rather than quantitative; too much now depends on the personal equation. Fortunately the present tendency is strongly toward quantitative microscopic examinations. Apparatus to determine hardness, critical points, strength, ductility, expansion etc. yield quantitative results in a large measure independent of the operator and to this extent they are satisfactory as well as useful.

The properties of any metal or alloy will depend on the nature and quantity of each constituent present, the properties of each constituent, and the arrangement of the constituents.

If some condition like the temperature or external pressure changes, then the properties of the metal or alloy will change in accordance with the change of properties of each constituent and the changes in quantity and arrangement of the constituents brought about by the changed condition.

The ultimate constituents are of course the electrons and atoms. If a line were drawn the width of 100 atoms, it would just be visible under the highest powered ultra-microscope. The smallest cube visible under the microscope would consist of more than a million atoms. The metallographic constituents capable of study under the microscope, therefore, must be confined to units larger than one million atoms. But owing to the wonderful developments of the modern physicist, the microscopist can think in terms of atoms even if he cannot see them. No doubt many of the unexplained variations in the properties of metals and alloys could be interpreted if we would extend our observations to the atoms rather than to groups of millions of atoms. The arrangement of the atoms involves the question of the arrangement of the constituents. The atoms of a crystal are arranged in a regular manner and of an amorphous substance in a haphazard manner. The difference in arrangement of the same atoms in the crystalline and amorphous states, produces a marked difference in properties. Internal stress in metals also involves a change of position of the atoms inasmuch as every stress is accompanied with a certain deformation or strain.

But in terms of what can be seen under the microscope, we are interested chiefly in those constituents which separate in relatively large masses. In pure

metals, solid solutions, and chemical compounds, so far as can be seen under the microscope, one constituent only is present. In other alloys more than one constituent can be seen. As the constituents vary in quantity the properties of the alloy change. With the same quantities of given constituents, the properties change in a marked degree with change in the arrangement of the constituents. A splendid example of this is found in 0.9 per cent carbon steel. In normal slow cooling there are two constituents, viz., ferrite about 86.5 per cent and cementite about 13.5 per cent. The cementite and ferrite are in the form of plates arranged in alternate layers. The elastic limit of the steel with this arrangement of the constituents may be over 50,000 pounds per square inch. With the same quantity of ferrite and cementite, the cementite can be spheroidized, that is, changed from flat plates to little spherical globules completely surrounded by ferrite, and the elastic limit may thus be reduced to 25,000 pounds per square inch.

The quantity and arrangement of the constituents of a given metal or alloy may be changed by heat treatment or by mechanical working. If the proper quantity of each constituent and the best arrangement for a given purpose are known, the microscope will aid in the production and control of the desired combination. It is necessary that the microscopist be able to identify the various constituents by means of the various etching and polishing treatments.

The use of metallographic apparatus in the development and control of metals for war materials is very extensive. Such companies as The American Steel & Wire Co., The Bethlehem Steel Co., The United Alloy and Steel Corp., The Halcomb Steel Co., The Carnegie Steel Co., The American Brass Co., The New Jersey Zinc Co., The National Lead Co., The Boston & Montana Copper Co., The Aluminum Co. of America, The General Electric Co., The International Nickel Co., and scorces of other companies use up-to-date microscopic and other metallographic means of control in the manufacture of their metal products.

War Uses of Metallography

Most of the steel now being manufactured is used for war purposes. Many users of steel such as the large automobile and airplane manufacturers, railroad companies, manufacturers of tools, guns, shells, armor plate etc. control their products by metallographic methods. The various departments of the Government dealing with the use of metals also use metallography to control the quality.

In making cannon, the thickness of the metal section is such that longitudinal and transverse tensile tests can be made. These tests show general tendencies as regards the directional properties of the steel due to casting and forging. A rifle barrel, on the other hand, is so small that the longitudinal tensile test only can be made. The directional properties of the steel in a rifle barrel, therefore, are best indicated by means of a microscopic examination. Non-metallic impurities such as slag and manganese sulphide can be seen under the microscope, the relative quantities ascertained, and predictions can be made regarding the effect on the physical properties. In this manner the microscope is used in conjunction with tensile and hardness tests to control the quality of steel used in rifle and machine gun barrels and other small fire arms.

The microscope is also used extensively for controlling the quality of brass and bronze. In brass the alpha and beta constituents can be differentiated, and the grain size ascertained. The grain size of brass is used generally to control the annealing operations. Metallographic control has aided greatly in the production of cartridge cases and other brass munition parts.

The arrangement and quantity of the various constituents in bearing metals as observed under the microscope enable one to predict the bearing properties better than any physical test outside a bearing test itself. While the application of the microscope in the control of bearing metals is not as extensive as it should be, its value has been recognized by several large companies, making bearings for machines to be used for war purposes.

New and Special Fields for Metallography

Metallographic control methods are now used extensively on castings of iron, brass, bronze and aluminium. The study of the constitution of some of the aluminium alloys has aided greatly in the knowledge of their properties and control. A new feature has been developed within the last few years, viz., the heat treatment of aluminium. Some of its alloys have critical points and can be hardened and strengthened and at the same time be made more ductile by heat-treatment processes. Rolled aluminium alloys are made now having tensile strength of 55,000 pounds per square inch and 20 per cent elongation in 2 inches.

Another field for metallography is the development of new and better products. Just as the metallographist frequently makes important scientific contributions to physics and chemistry, so do workers in all branches of industry and science add to the sum total of metallographic knowledge and hence to the new developments. In fact, some of the new developments come from unexpected quarters. Sometimes the developments are the results of accident, but they are generally the result of scientific elimination. The science of elimination consists largely in the choice of the proper scope of materials and processes to produce a certain product and the elimination of all but the most suitable by planning experiments to study one variable at a time.

In this connection such men as H. M. Howe, Bradley Stoughton, R. R. Abbott and P. D. Merica are working practically their entire time on development problems in the United States. A. Sauveur is doing work in France for the United States Government along metal development lines. Many metallographists of England and France are engaged in the same kind of work for their Governments.

In addition to this many of the large industrial companies are carrying on research work to produce better alloy combinations and better treatments. In particular, great strides have been made in the production and treatment of special steels for aircraft-motor construction and for armor plate. The details of these developments probably will not be made public until the close of the war. Only when the details are made public can the magnitude and importance of this development work be adequately appreciated.

Cleveland, O.

Chemical Iron Ware

A Description of the Silicon Irons—Acid-Resisting, a Relative Term—Comparative Action of Corrosives—Acid Resisting Castings

RECENTLY considerable controversy has arisen in England over a paper read by Professor Camille Matignon before the Academic des Sciences of Paris[1] on his investigations of various commercial alloys of ferrosilicon. Starting his investigation in 1913, at the very start of the commercial development of this industry, Dr. Matignon had great difficulty in getting samples, so that his report probably did not represent simultaneous comparisons of the various products.

Considering the rapid developments being made in this field, no report less than present day comparisons is of value. Several concerns are manufacturing this type of chemical ware in America. The compositions of six of the alloys analysed by Dr. Matignon are reported as follows:

	Métilluro	Elianite I	Elianite II	Ironac	Duriron	Ferroboron
Si	16.92	15.07	15.13	13.16	15.51	4.9
Fe	81.05	82.40	80.87	83.99	82.23	69.8
Mn	0.88	0.62	0.53	0.77	0.66	3.3
Ni	.....	.....	2.23	.....	.....	.....
Al	0.25	.....	.....	.....	.....	3.1
C	0.592	.....	.82	1.08	0.83	.....
P	0.173	.....	0.06	0.78	0.57	.....
S	0.01	.....	0.03	0.05	0.01	.....
Ca and Mg	.....	.....	.....	.....	.....	.....
B	.....	.....	.....	.....	.....	15.4

The following are extracts from *Engineering*, Vol. CVI, pp. 154-156, Aug. 9, 1918, giving a full account of tantiron. While it does not pretend to offer a comparison of the several products, it shows the present status of this industry in England and America.

The manufacturing chemist and metallurgist are greatly restricted by the limitations of applicability of their apparatus. In many processes, the difficulty is not so much to obtain the raw materials as to find furnaces, containers, pipes etc., that will bear the chemical and physical stress of the reactions, and to avoid the contamination of the products by the substances with which the reactions bring them into contact. For these reasons many a promising process never gets beyond the laboratory stage; hence, also, the cry for substitutes of rare, expensive materials, as well as the natural distrust of them. The enhanced activity of certain chemical industries has much increased the demand for refractory materials and acid-resisting alloys. Experiments with acid-resisting iron alloys are not new, of course. Wollaston made a silicon-iron, and he may not have been the first. Engineers and electricians found silicon-iron very useful for special purposes, and many attempts were made to construct chemical plant of silicon-iron and other iron alloys. Tungsten, chromium and nickel were tried. But foundrymen seemed to be unable to make vessels even of moderate dimensions of such materials, and it was not till 1912 that an acid-resisting iron alloy of sufficient uniformity and strength for the engineer to deal with was put on the market.

[1] *Comptes-Rendus de l'Academie des Science*, Vol. 166, pp. 815-818, May 21, 1918.

It was the tantiron of Mr. R. N. Lennox, made by the Lennox Foundry Co. of Glenville Grove, New Cross, S. E. Since then silicon-iron and other non-corrosive iron alloys have been brought out by several firms. Both the "duriron" of the Duriron Castings Co. of Dayton, Ohio, and the "ironac" of the Houghton Co. of London, are silicon-irons, like the métillures of A. Jouve, one of the first in this field, and the Italian eleanites, which contain about 2 per cent of nickel. The American rights for tantiron were taken over in 1913 by the Bethlehem Foundry and Machine Co., Pennsylvania. "Ferrochrome" is supplied by the Electrometallurgical Co. of Niagara Falls; the "feralun" is likewise an American product, and German activity in the field will not have ceased during the war; in addition to "neutraleisen," there are ferro-chromes and ferro-borons.

Acid-Resisting Is A Relative Term

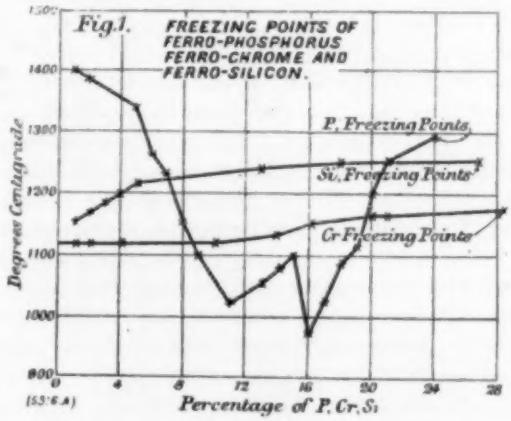
Tantiron is a silicon-iron, containing about 15 per cent of silicon. In appearance it is a silvery-white close-grained cast-iron, and has the general properties of a machinable cast-iron. One special brand of tantiron is very hard, and not machinable; another quality resists hydrochloric acid which the others do not. It melts at about 1200 deg. C., can be cast, ground with carborundum, cut with the saw, drilled, screw-cut and tapped etc. Sofar as chemical and mechanical corrosion is concerned, it is a superior iron and is used for cast vessels or in the shape of linings for those of steel or iron. It does not rust, except at the skin, and the rust is removed by pickling in diluted sulphuric acid or by grinding. The tantiron itself is not—or practically not—attacked by sulphuric, nitric, or acetic acid, concentrated or diluted, boiling or cold, and indeed not by most chemicals. One kind already mentioned—a more recent invention—also resists hydrochloric acid equally well. Carbonic acid attacks it slightly, but the corrosion is only about one-thousandth that of cast-iron. Alkalis corrode it about as much as they do cast-iron; chlorates and perchlorates do not corrode it, and it will resist chlorine gas up to a temperature of 105 deg. C. But sulphur dioxide corrodes tantiron badly. In view of this latter fact, the suitability of tantiron pans and basins for the concentration of sulphuric acid is rather surprising. Large pans have been in use, however, we are informed, since 1912, and some 25,000 basins are actually in use in sulphuric-acid works. There is some slight corrosion, of course, and there are breakages, partly due to the material, partly to improper treatment by unskilled labor, which causes many small and large accidents in these days of rapid plant erection and high-pressure activity. The maintenance cost of pans and basins is about 2½*d.* or 3*d.* per ton of acid concentrated. After boiling 100 grams of the alloy for

17 hours, 10 per cent sulphuric acid was found to have dissolved 0.13 gram of tantiron, 25 per cent nitric acid 0.25 gram, and 30 per cent hydrochlorid acid 0.16 gram.

The term "non-corrodible and acid-resisting iron" is misleading, as all such general terms are. Every chemist knows that he must not allow metals to glow in his platinum crucible, as they would form fusible platinum alloys, and that caustic alkalis and certain alkali salts, and even the sooty flame of the gas burner, will ruin his crucible. Tantiron also has its peculiar weaknesses. It resists hot sulphuric acid much better than cold acid, and many instances of attack are so far inexplicable. In one case, a tantiron tower containing vapors from boiling sulphuric acid showed defects in the top sections, without any attacks on the bottom sections. The top sections were replaced several times; the bottom sections, which had been in use for eighteen months, were taken out and inserted in the top, when they were attacked within a fortnight; yet temperature determinations at different points of the tower never showed differences exceeding 5 deg. C. In other cases, supply missing part sulphuric acid, are being carefully freed from arsenic by sulphuretted hydrogen, attacked the tantiron nearly three times as quickly as the original acid. But the amount of attack is, of course, exceedingly small. A tantiron vessel weighing 4950 grams had 600 tons of sulphuric acid passed through it during concentration with a total loss of weight of 12 grams. The attack is namely on the surface or skin, which should, therefore, be removed when corrosion tests are conducted.

Chemical Composition and Physical Properties of Tantiron

Though the iron carbide seems chiefly to be attacked, the corrosion is apparently uniform; under the microscope, acid-corroded tantiron keeps its smooth surface, while cast-iron shows irregular corrosion. Mr. Lennox prefers to have no carbon in the iron at all. His raw materials are cast-iron, scrap, and old tantiron, and further ferro-silicon. The latter is obtained with about 12 per cent silicon from Middlesborough, and in a 50 per cent grade from Norway. The average composition of tantiron is in per cent: Silicon, 14 or 15; total carbon, from 0.2 to 0.6; manganese, 0.25 to 0.35; phosphorus, 0.16 to 0.20; sulphur, under 0.05. The three kinds mentioned, machinable tantiron, hard tantiron and tantiron for hydrochloric acid, differ little in composition, but the small fractions of additional constitutents are very important. To study their influence, ingots are poured from furnace charges of 1 ton, to which additions are made in very small increments; the ingots are then tested chemically and mechanically. The sulphur and manganese, in their percentage, seem to be of no consequence. The phosphorus is deleterious, mainly probably because it is not uniformly distributed, but concentrated in spots. As phosphorus is added to iron, the freezing point is first lowered, and then, when 10 per cent of phosphorus is exceeded, rises again, but the cooling curves are not regular, while the freezing point curves of silicon-iron and chrome-iron show a very slow but steady rise with increasing percentages of those elements. (See Fig. 1.) Impact tests are made on ¾-in. square bars, which are not notched; they break, e.g., under stresses of from 8 ft.-lb. to 10 ft.-lb., against 12 ft.-lb. to 14 ft.-lb. in the case of cast iron. On the whole, the strength of tantiron is about 25 per cent less than that of cast iron. The following is a summary of the comparative properties of tantiron and cast iron (the latter figures in brackets): Density, 6.8 to 7.0 (7.3); tensile strength, 6 to 7 (9 to 10) tons per sq. in.; transverse strength, bars of 12 in. by 1 in., 1600 lb. (2500 lb.); crushing strength per inch tube, 34 (40) ions; melting point, 1200 (1500) deg. C.; hardness, 1.6 (1); heat conductivity, 8 (10); electrical resistance, 10 (8); resistance to corrosion, 1000 (1); contraction allowance in casting, $\frac{3}{16}$ ($\frac{1}{8}$) in. per ft. As regards



other properties, also of other materials, the comparative order for iron, tantiron, lead, quartz, and stoneware is: Transmission of heat, 230, 215, 115, 28, 20; hardness, 24, 35, 1, 52, 32; density, 7.3, 7, 11.3, 2.6, 2.0; melting point, 1150, 1200, 335, 1900, 1800 deg. C.

Comparative Action of Corrosives

With respect to corrosion by chemicals, there is generally a first attack, followed by relative immunity under continued exposure. The following figures indicate the percentage losses of tantiron after boiling for 24, 48, 72 hours; the greater action during the first 24 hours is largely due to the already-mentioned skin effect, the outer surface having been changed by contact with the sand in which the tantiron is cast; this skin is removed in the foundry, as we stated.

	First 24 Hours	Second 24 Hours	Third 24 Hours
Sulphuric acid, 98 per cent	0.10	0.02	0.02
Sulphuric acid, 30 per cent	0.07	0.00	0.00
Nitric acid, 1.4	0.03	0.01	0.00
Nitric acid, 1.1	0.01	0.00	0.00
Acetic acid, 60 per cent	0.03	0.01	0.00
Chromic acid, 10 per cent	0.07	0.00	0.00
Tartaric acid, 25 per cent	0.05	0.03	0.03
Iodine (sat. sol.)	0.00	0.00	0.00
Bromine water (sat.)	0.01	0.01	0.00
Bleaching powder (sat. sol.)	0.04	0.01	0.01
Copper sulphate (acid sol.)	0.00	0.00	0.00
Copper sulphate (alkaline)	0.00	0.00	0.00
Ferric sulphate (sol.)	0.06	0.00	0.00
Zinc chloride, 30 per cent	0.03	0.00	0.00
Ammonium chloride sol.	0.05	0.02	0.01
Fused sulphur	0.06	0.01	0.00
Fused nitrate of ammonia	0.00	....	0.00

To meet the peculiarities of the material, it is desirable that designers of parts to be made in tantiron should bear the following rules in mind: large flat surfaces should be avoided; corners be rounded; slots be used by preference to bolt holes; facing strips be narrow and of ample height; the effects of expansion and contraction should be well-considered; coreing and

moulding be made easy, by preference without the use of chaplets to support cores. Among the chief products now made wholly or partly of tantiron are acid pans, basins, stills, bleachers, denitrating towers, autoclaves, condensers, pumps, stop cocks, valves, pipes and fittings, electrodes etc. Frequently a tantiron lining will suffice to prevent either chemical or mechanical erosion. The largest tantiron casting so far constructed weighed 7½ tons.

The greatest care is bestowed upon clean moulding, which is mostly done by women, and use is made of rotating strickles in preparing the moulds for parts of circular section. For lining pipes with a tantiron, the pipe must be suspended vertically by a flange with the core in proper position, the pipe to be lined being weighted below; if the liquid tantiron were poured into a horizontal pipe, the pipe would curve. This practice is generally adopted for lining iron or steel, wherever possible, and the part to be lined is well dried, but not pre-heated. The adhesion between the iron and the tantiron is said to be good fusion taking place between the surfaces; the adhesion is tested with the acid of paraffin oil. The lining may have a thickness from ¼ in. up to 1¼ in. and more. The subsequent finishing of the product is largely done with the aid of carborundum wheels and grinders. It is rather curious that the fine tantiron particles torn off by the tools do not spark; there is only a glow. Drills, saws and planers are also used.

Acid Resisting Castings

The basins for the heating and concentration of sulphuric are mostly of the plain porcelain dish style, but are provided both with a lip and an arc-shaped baffle (not shown); they are supplied also in the Webb and

FIG. 2.—CASCADE ACID CONCENTRATING BASINS

Dyson styles (Fig. 2). The basins are arranged in cascade, so that the hot acid drips from the lips of one basin into the one next below, and the baffle prevents the acid from streaming right over the basins to the lip. Provisions for more efficient circulation and stirring of the acid in the basin is made in the "Mackenzie field tube evaporator basins," also supplied by Mr. Lennox; this style has calix shape, being a tube opening out into a basin; a "field" tube fits concentrically into the cylindrical portion and promotes active circulation. Other basins are provided with covers and necks, and made corrugated, and they serve generally also for the concentration of corrosive liquids, such as zinc chloride, lead nitrate, etc.

The concentration of nitric acid requires more varied apparatus, which have successfully been made of stoneware in the past few decades. When the war broke out, the stoneware works of this country were not able to deal with the demands, and tantiron vessels, which can be made in a few days, while good stoneware requires months, were largely adopted. Valentiner plants comprising a still, condenser and coils, built up of pipes and return bends flanged together, all of tantiron, are now made. The denitrating tower illustrated in Fig. 3 is an interesting novelty. The spent acid of nitroglycerin works consists of diluted sulphuric acid, which has to be concentrated again, and some nitric acid, which is to be regained by distillation. There may also be small globules of oily nitroglycerin which might coalesce if the evaporation were carried on in pans. The tower, 15 ft. high, is built up of socket pipes, 14 in. in diameter, and is packed with quartz fragments; the acid enters at the top and steam at the bottom, and the nitric acid and vapor condense in the cylinder by the side of the tower. Nitric-acid stills are also used for the distillation of acetic acid. The autoclaves for making ammonium nitrate from cyanamide at a temperature of 120 deg. C. and a pressure of about 2 atmospheres resemble one style of nitric acid retorts. The outer vessel is a jacket of cast iron, the inner vessel of tantiron forms the saturator; the height is 8½ ft., and the diameter 4½ feet.

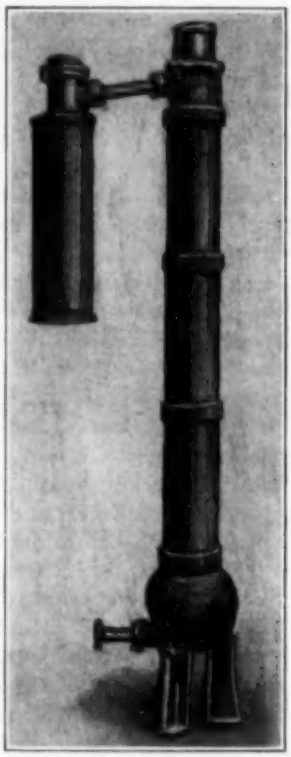


FIG. 3.—DENITRATING TOWER

Acid eggs, apparatus for forcing up corrosive liquids with the aid of compressed air, are made of two tantiron cups, joined by their top flanges so as to form a horizontal cylinder with spherical ends and one common flange on the vertical middle plane; they are provided with acid inlet and outlet valves and an air pipe, and are supplied in large sizes. The pumps of the works, reciprocating and centrifugal, do not differ much in appearance from ordinary pumps; the barrels and impellers and pipes are made of tantiron or lined with it. As these parts of hard tantiron cannot be machined or repaired, it is recommended to keep spare parts ready for cases of accident. Centrifugal pumps are supplied for lifting 6000 gals. of acid or corrosive water, etc., per hour, against a head of 50 ft., running at 1600 r.p.m. Slime pumps for conveying the crushed quartz in gold mines are likewise made of tantiron, to obviate the heavy erosion of the pipes by the gritty quartz particles. For the same reason, tantiron-lined steel pipes are used in the Rand mines, South Africa, for the sand-filling plant. When the pillars left in the galleries below are to be removed, the galleries have to be refilled with the finely crushed quartz from the vast white waste mounds which form a conspicuous feature of the district. The spoil is flushed down the pipes with water. The first pipes used, steel pipes, were ruined

by 6000 tons of sand; porcelain-lined pipes were then tried, which could stand up to 50,000 tons; the tantiron pipes, introduced four years ago, are still doing duty, and their life capacity is estimated at 500,000 tons. Similarly-lined steel pipes and tantiron pipes, up to 2 ft. in diameter, are in use for ash ejectors, especially on board ship where heavy erosion and corrosion by the caustic ashes and the sea water have to be guarded against.

In stop cocks and valves of tantiron, corrosion by acid sodium bisulphate (the acid cake residue of the distillation of nitric acid from salt and sulphuric acid) ersion by grit, rusting and sticking are the chief sources of trouble to be met. Here, again, tantiron completes with lead and stoneware, and its advantages lie in greater strength and indifference to high temperatures and frost. A great variety of cocks, valves, T-pieces, straight and bent socketed pipes, provided with threads, are made in tantiron.

Of other specialties, we mention the corrosive-vapor drying and baking ovens, the flat doors and walls of which are lined with sheets of tantiron, which are screwed on. Tantiron can be rolled at about 700 deg. C., but is brittle then. Another specialty is the tantiron electrode for cyanide baths (silver and gold), and also copper baths etc., replacing iron and other alloy electrodes, which are not insoluble, and very objectionable on this account, or more expensive than tantiron. For the same reason, steel-mixing mills for the manufacture of manganates, the balls and stirrers of other mills, and many apparatus used in the acid and dye and other chemical industries, are made of tantiron.

Like every manufactured article, tantiron is constantly being improved, and does not claim to have reached final perfection. Acid-resisting materials must possess various properties which are not easily combined, and possibly not capable of combination. A compromise has to be accepted.

Ulco Hard Metal

By Francis C. Frary and Sterling N. Temple

THE development of this new hard-lead alloy may be considered as a by-product of the war and also of the Atlantic City meeting of the American Electrochemical Society. At the time of this meeting, in the spring of 1915, the heavy demand had raised the price of antimony to some seven times its normal value, and the larger consumers were naturally looking for substitutes. Mr. H. B. Coho, formerly chairman of the New York Section of the American Electrochemical Society, in talking with one of the authors at that meeting, mentioned the need of a substitute for antimony in hard lead, suggesting cerium, and explaining the interest which the United Lead Co., with which he was connected, had in such an alloy.

It so happened that in the work done by Frary and Badger[1] on the production of metallic calcium, one lot of lead-calcium alloy had been made, and the fact noted that it was harder than lead. Calcium being easier to produce than cerium, it was considered a better starting point for experimental work. But when the calcium-lead alloys were studied we found that a considerable amount of calcium must be used in order to get a hardness approaching that of antimonial lead (17 Brinell), and that this alloy did not stand remelting but easily lost its calcium. Upon making up similar alloys of lead with other metals of the alkaline earths, it was found that each hardened lead to a different but marked degree. Further experimentation brought to light the surprising fact that if two or more of the metals were used together, the hardening effect was several times that which would have been found if only one were present in the same total quantity, thus making it possible to produce an alloy which was harder than antimonial lead, but contained so little alkaline earth metal that it could be remelted several times without losing appreciably in hardness, and actually contained well over 99 per cent lead.

Metal is Hard and Casts Free from Blow Holes

The rights to this alloy (U. S. Patents 1,158,671 to 1,158,675 inclusive, and corresponding foreign patents) were acquired by the United Lead Co., who proceeded to install a plant at Keokuk for its manufacture. The surprising toughness of the metal, the possibility of making it much harder than any other commercial lead alloy (some samples have been made which were as hard as steel) and the fact that it made castings entirely free from any trace of blow-holes and expanded to fill a void, like type-metal, made both the inventors and the company feel that it would have a useful function to perform, even though, in the mean time, the price of antimony had dropped to a point where the new alloy could scarcely compete for ordinary uses.

Test by Bureau of Standards

These hopes have been fulfilled and the alloy has taken its place among the important bearing metals, its high melting point, excellent structure and low coefficient of friction giving it a unique importance. The following report of tests from the U. S. Bureau of Standards confirms in an official way the experience of a number of firms who have experimented with it:

> A 10-lb. ingot of the Ulco Hard Metal, the original Brinell hardness numeral of which was 25.2 at a load of 500 kg., was melted down, and chilled castings were poured at various temperatures with the following results:

Temp., Deg. F.	Temp., Deg. C.	Brinell Hardness Numeral
650	343	23.5
700	371	25.1
750	399	25.0
800	427	25.7
900	482	22.8
1,000	538	22.0

> The metal was fluid at 650 deg. F., and though the maximum hardness was produced by pouring at a temperature of about 800 deg. F., the hardness was not greatly reduced by pouring at higher temperatures.
>
> Test bearings were then poured and service tests made in an Olsen testing machine, tests on genuine babbitt being made at the same time to serve as a basis for comparison. The table below gives the results of these service tests:

GENUINE BABBITT

Load lb. per sq.in.	R.P.M.	Total No. of Revolutions	Final Temp., Deg. C.	Final Temp., Deg. F.	Rise in Temp. Deg. C.	Rise in Temp. Deg. F.	Friction, Lb.	Loss in Weight Gram	
100	694	12,230	89	192	53	95	22	0.023	
200	706	16,510	102	216	58	104	29	0.021	
300	682	15,150	125	257	100	180	38	0.013	(a)
400	603	6,600	139	282	94	169	79	0.054	(b)

(a) Belt slipping. (b) Bearing seized and smoking.

[1] *Transactions*, Amer. Electrochem. Soc., 16, 185 (1909).

ULCO HARD METAL

100	710	13,160	56	133	23	41	13	0.013
200	715	18,870	69	156	33	59	18	0.021
300	719	18,830	80	176	42	76	27	0.013
400	711	17,310	81	178	43	77	23	0.022
500	723	17,660	79	174	43	77	25	0.014
600	692	14,960	84	183	45	81	24	0.021
700	648	24,520	62	144	38	68	24	0.020
800	365	12,870	53	127	20	36	23	0.010
900	408	22,300	59	138	22	40	24	0.015
1,000	405	23,200	66	151	36	65	22	0.014 (a)

(a) Bearing still in good condition.

The Ulco Hard Metal bearing was still running excellently at 100 lb. per sq.in. load, but as the capacity of the testing machine was reached the bearing could not run to failure, as in the case of the genuine babbitt bearing.

It will be noticed that the Ulco Hard Metal ran considerably cooler than the genuine babbitt, the friction was less and the wear also a smaller amount. It should be borne in mind that the specific gravity of the Ulco Hard Metal is much greater than that of genuine babbitt, and for equal loss in weight the volume loss would be less in the case of Ulco Hard Metal.

These tests were repeated on new samples with substantially the same results as above. A test was also made in which no lubricant of any kind was used in the bearing. The bearing was run at a speed of 700 r.p.m. and 50 lb. per sq.in. pressure, and after about 10 min. the metal began to flow and adhere to the steel shaft, scraping out more of the metal from the bearing. The shaft was not injured in the least by the test, and the metal that had adhered to it could be readily removed with a knife.

Tensile tests on Ulco Hard Metal and genuine babbitt cast under similar conditions gave the following results:

	Tensile Strength, Lb. Sq.In.	Elongation, Per Cent in 1 In.	Reduction of Area, Per Cent
Genuine Babbitt	10,600	15	8
Ulco Hard Metal	13,000	5	1

The fracture of the babbitt showed blow-holes, reducing section approximately one-fourth, though the Ulco specimens were sound throughout. The average elastic limit in compression of Ulco hard metal was found to be 11,525 lb. per sq.in.

Alloy Resembles Lead in Many Respects

The alloy has the general appearance of lead, may be cast, drawn, rolled or extruded; its specific gravity and melting point are practically identical with those of lead, and its composition so nearly the same that two analysts reported it as (1) commercially pure lead, (2) pure lead, heat treated. It may be diluted with ordinary lead to produce alloys which are not so hard, and tin and bismuth may be added if desired, but if more than a very small amount of antimony be added, the alkaline earth metal separates out and the alloy is ruined. It has the metallic ring of bell metal, and none of the brittleness of antimonial lead.

One of its peculiar properties which will doubtless interest metallographers is its pronounced increase in hardness upon standing or aging, and the possibility of accelerating this process by aging at steam heat. It is a fact not generally known or noticed that antimonial lead increases slightly in hardness for a few hours after casting, but the amount of this change is not large. With the lead-alkaline earth alloys, however, the fact was noticed early in the experimental work that all samples increased markedly in hardness for some time after being cast, so that it was entirely impossible to determine the hardness of the alloy until it had aged several days. Figures obtained in the research laboratories of the United Lead Co. show that an alloy with the Brinell number of 8 increased to 10 on standing a day, another with an initial hardness of between 13 and 16 reached 17.6 after standing two days, 19.6 after standing eight days, and 20.7 after fifteen days. A part of the same sample, after being aged one day at 100 deg. C. had attained a hardness of 25.4.

Solid Solution of Alkaline-Earth Metals in Lead

Bars of the metal which have been cast in an iron mold and broken seem to show a slight difference in fracture which would indicate a chill effect at the surface which was in contact with the iron. The main body of the bar will exhibit a fine hackly fracture, like an alloy steel,

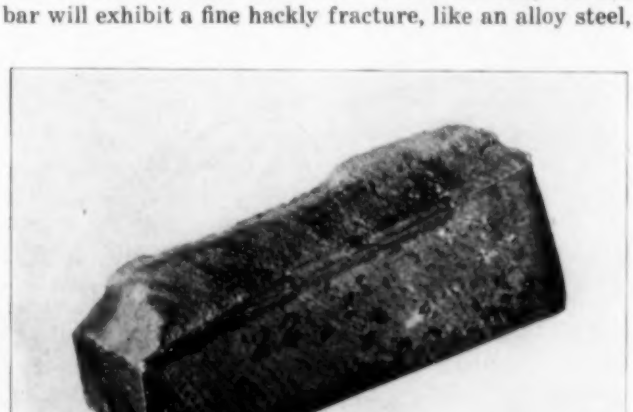


FIG. 1.—SECTION FROM A PIG OF ULCO LEAD SHOWING FRACTURE

but a more distinctly crystalline structure appears for a depth of about $\frac{1}{32}$ in. from each surface which was in contact with the mold. The effect is absent at the surface which formed the top of the ingot. Such metallographic work as has been done upon the alloy has not, as far as we are aware, developed any definite structure, and everything seems to indicate that we have to deal with a solid solution of the alkaline-earth metals in lead. This is true only for alloys containing small amounts of the alkaline-earth metals such as Ulco Hard Metal; these are stable toward water and have no taste, while alloys with several per cent of the metals break with a coarser structure and have the "electrolytic" taste with which everyone is familiar who has tried to test a dry battery by taste.

The possibility of using this alloy to replace babbitt and thus save tin for war uses is of course very important now, and its superior quality would indicate that such a substitution would not be disadvantageous. It has also found a field in the manufacture of various small castings; bath-room supply and waste pipes, nickel-plated, are at present made from it, and its hardness combined with ease of casting should recommend it for various other small castings, now made of brass.

Tin Mining is very profitable in Bolivia at present prices. The Llallagua Tin Co. made a gross profit of eight and one-half million dolars in 1917, which is about four times that of the year previous. Their production of ore concentrates increased from 7460 long tons in 1916 to 11,250 tons last year. The mine showings are figured at 261,902 tons; averaged at 14.33 per cent, they are estimated to offer 37,500 tons of metallic tin.

Magnesium

Some of Its Present Commercial Applications

MAGNESIUM, the lightest of commercial metals, was little known and little used in this country before the outbreak of the war in 1914. Prior to that time a small amount of this metal was imported in powder form for flash-lighting, and a few manufacturers used it in stick form with the metals.

The withdrawal of the German product from the market necessitated the development of its manufacture in this country to supply the existing demands. Allied purchases in the United States and our own entrance into the war have stimulated the production to a marked degree, on account of its use for flares and illuminating bombs of all kinds. Government bulletins show an increase in production in the United States, from 75,400 lb. in 1916 to 115,800 lb. in 1917, and to 116,938 lb. in the first six months in 1918.

Magnesium is a common element in many minerals occurring in America so that its production, like that of aluminium, can be increased to meet almost any demand. All that is necessary is to develop our water power, as cheap power is essential to the production of this metal. This possible future development is vital to those who are now using magnesium and to others who are contemplating its use.

We are today only learning how to use metals, and the future of the metal industry, in the application of alloys to various uses, will be like rubbing Aladdin's lamp. The future uses of magnesium may be as large a factor in revolutionizing industry as aluminium has been. Magnesium, however, cannot be said to be a competitor of aluminium; it is a co-worker with that metal. In other words, where it will replace aluminium in one industry, it will create a much greater use for it in others.

Magnesium in aluminium is, then, one of the present commercial uses. The first action of magnesium in aluminium is as a deoxidizing agent. At the temperature of molten aluminium, magnesium will reduce carbon monoxide and carbon dioxide, gases which are readily dissolved in molten aluminium and which cause endless trouble in cooling. As a result of its deoxidizing properties, it makes aluminium castings more dense.

All of the magnesium introduced into aluminium is not consumed in deoxidizing, and the resulting alloy is a much improved metal. As an alloy, magnesium makes aluminium stronger and gives it a finer grain. In addition to this it improves its machining qualities.

While all of these qualities are obtained with ½ per cent, an increase in the amount of magnesium with an equal percentage of copper gives a very dense metal. For instance, a 3-in. flanged valve with ⅜-in. wall (96 per cent Al, 2 per cent Cu, 2 per cent Mg) was tested to 300 lb. per sq.in. hydraulic pressure without leaking. This valve is now in service under 400 lb. per sq.in. pressure of acetic acid. Other tests have shown equally good results with this alloy.

The commercial advantage of an alloy of this sort is illustrated in a comparison of its price with that of brass or bronze. Considering metal costs only, brass will cost about $0.26 per lb. and the aluminium alloy about $0.43 per lb., but the difference in the specific gravity (the aluminium alloy is about 1/3 that of brass) makes the price for any individual piece or casting much less. That is, a brass casting weighing 1 lb. would have a metal cost of $0.26 per lb. whereas the same casting made of the aluminium-alloy would cost 1/3 of $0.43 or $0.14 1/3. The advantages here are evident, especially in view of the fact that aluminium takes a better and a more acid and alkali-resisting polish when it contains a small percentage of magnesium.

The deoxidizing properties of magnesium have been known and applied commercially for ten or fifteen years. Magnesium is used to deoxidize nickel and monel-metal castings; in fact, it is quite essential in this industry.

The same property has recently been applied to the making of copper castings and with some very far reaching possibilities. In deoxidizing copper, magnesium is used in proportions of 0.03 per cent to 0.08 per cent, that is, 1 lb. of magnesium will deoxidize from 1200 to 3000 lb. of copper. As 80 per cent to 90 per cent of the magnesium introduced is consumed in deoxidizing, practically none of it shows in the analysis of the finished casting. Magnesium also gives a very dense metal, so that it is possible to make copper castings having electrical conductivity equal to, if not greater than, that of rolled electrolytic copper. The development of this use in the electrical industry makes possible the substitution of copper castings for machined copper thus saving machining costs, reducing the copper scrap and decreasing production costs. Other applications may follow this important use for magnesium.

The action of magnesium in brasses and bronzes is similar to that in copper and an equal amount of magnesium will deoxidize these alloys. As a deoxidizing agent in these alloys, magnesium is cheaper than phosphorus or phosphor-copper, and may be used in their place, except where specifications require a final analysis showing phosphorus. Its cheapness, combined with the fact that it gives a dense and stronger casting, will greatly increase its use in this branch of the metal industry.

A remarkable result of introducing less than 0.1 per cent of magnesium in brasses is that the tensile strength of a brass will be increased from 40 to 60 per cent. This is not obtained at the expense of elongation or ductility as the elongation is increased at the same time.

Magnesium, contrary to the usual rule, is a good bearing metal. Some of its alloys have wearing qualities equal if not superior to cast iron. Its hardness is somewhat greater than that of tin and its heat conductivity is exceeded only by silver, gold and copper. When its specific gravity is taken into consideration, its price per unit of volume is now one-half that of tin.

Magnesium is ductile and may be worked at temperatures between 300 and 400 deg. C. It may also be rolled into sheets, drawn into wire and produced in many commercial forms. As these and many other uses are future possibilities rather than present applications they need not be discussed here. Its use as a deoxidizer of other metals and alloys, however, is widespread and is helping in no small way to win the war.

A Statistical Summary of Tin

A Review of the Development of the Economic Uses of Tin—History of Its Commerce—Production, Consumption and Average Prices—Measures Taken to Reduce Consumption

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AT THE inter-allied conference recently held in London it was decided to allot to the United States about 80,000 tons of pig tin or two-thirds of the world's entire production annually. Thus was our preëminence as a tin consumer recognized. Tin has been known to man from prehistoric time. The introduction of the use of tin as an unalloyed metal took place at a much later date than its first use as a constituent of bronze. When it was first recognized in the pure form is not known, but we do know that its Latin name, stannum, took final form in the fourth century, and that tin was imported from Cornwall into Italy after the Roman invasion. Increase in the production of tin and in its use has taken place gradually through a long period of time. During the eighteenth century the world's supply of tin was mainly drawn from the deposits of England, Saxony and Bohemia. The total amount produced, however, cannot have been very large, for in 1801 but 2,500 tons were produced in England. The nineteenth century witnessed the predominence of the English mines, whose output remained at about 10,000 tons for the most of the last half of the century. During the last decade of the nineteenth century, however, the yield in Cornwall declined very much and since 1900 has been around 5000 tons annually.

In the opening decades of the nineteenth century supplies began to be drawn from the Island of Banca in the Dutch East Indies. Billiton became of note in 1863 with a production of 40 tons. The Straits Settlements became an important producer in 1870 when the total amount mined there was 2337 tons. At the present time the chief producing regions of the world are the Straits Settlements, Bolivia, Dutch East Indies, notably Banca and Billiton, South Africa, Cornwall, China and Australia. The Straits Settlements produces approximately half of the entire output of the world.

Uses of Tin

The uses to which tin is put in modern industry are very numerous. The largest single demand for tin comes in the manufacture of tin-plate and terne plate. Tin-plate is used for making receptacles of all kinds—kitchenware and containers for a great variety of produucts, both food and non-food.

The greatest single source of demand for tin-plate is for food containers. In 1914 the amount of tin-plate used for food cans and caps was sixty-five per cent of the total tin-plate manufactured. Estimates for 1917 indicate that at least seventy-five per cent was so used during that year. The process of canning was discovered in France in 1810 by Nicholas Appert of Chalons-on-the-Marne, and throughout its development has been intimately associated with the waging of war. This form of food preservation was conceived primarily as a military measure to secure better stores for the army and navy. The canning industry began in France and the British Isles almost simultaneously, and was brought soon after to the United States, where it has attained its highest development. Very little progress was made in the industry prior to 1855 in this country, the principal pack being sea-food. It was during the decade of the Civil War that the superiority of canned foods over those which were dried, salted and pickled became common knowledge. The soldiers in detention camps and hospitals, although they were supplied with very small quantities, realized the excellent values of canned foods and carried the knowledge home.

The necessity for the preservation and shipment of a great variety of food products to the armies in France, both our own and those of our allies, has again caused an expension of the canning industry and has rendered the tin supply a question of vital interest because of its intimate connection with the prosecution of the war. One-tenth or more of the tin-plate used in the United States for packing food goes into cans for condensed milk and evaporated milk. This ratio has not been increasing to any marked degree because the increase in other branches of food canned has almost kept pace with the increase in tinned milk production. For his canned milk alone it is estimated that each soldier will require five pounds of tin-plate per year.

Tin and tin-plate also have other important uses from a military standpoint besides the necessity for food containers. Tin-plate is used for cans for carrying gasolene to the front, for cases for shells etc. A considerable amount of babbitt metal containing tin is used in certain bearings in naval and other military machinery. It was to secure an adequate supply of tin for Government war work that tin stocks were commandeered in this country at various times during the winter.

Terne-plate is prepared with an alloy of tin and lead and is largely used in metal roofing. In addition to the alloy used to make terne-plate there are a number of other important tin alloys; bronze, for instance, is an alloy of tin and copper; babbitt metal, used in the bearings of machinery, is an alloy of copper, antimony and tin; and pewter is composed of various mixtures of tin with other metals.

Tin is used likewise to weight silk and in the manufacture of tin foil, parts of motors and machinery, wire, rubber, and chemicals. Many other industries use tin in small amounts as alloys or otherwise. Although their demand is not large, tin is none the less indispensable to their uninterrupted operation.

The increase in the production and consumption of tin in the last twenty years has been tremendous. In 1897 the total production of the world was 73,499 tons. In 1907 it had increased to 92,290 tons, while in 1917 the world's production was 120,918 tons, an increase of 65 per cent in twenty years.[1]

Relation of U. S. to World Supply

Although the United States is the greatest consumer of tin in the world, tin in commercial quantities is not produced within our borders. Alaska produced ninety-one gross tons in 1915 and one hundred twenty-five gross tons in 1916. Beyond this very limited Alaskan output, our tin production is entirely negligible, although there are a few scattering deposits in a number of states. The problem of our tin supply, therefore, is the problem of the world's tin supply and our relation to it as a buyer in the international market.

Straits tin is by far the largest factor in the world's market. Next in importance is Bolivian tin, while Banca tin is third. There are also Chinese, English, Australian, and South African tin, but they have always been regarded as of minor importance.

The United Kingdom, through her intimate connection with most of the important producing regions, is in a dominant position as to the tin market of the world. The Straits Settlements, Australia, South Africa and Cornwall, both as to tin production and shipment, are all British controlled. In 1917 the tin from these sources comprised sixty-two per cent of the entire world output.

With the exception of England, the regions from which the world's supplies of tin come are not consumers of tin, and the record of their shipments is the index to their production. Table I, therefore, indicates with approximate accuracy world tin production from 1908 to 1917:

The tin output of the Malay Peninsula, including the Straits Settlements and the Federated Malay States, is so imporant that it deserves special attention. The combined output of the British possessions and protectorates in this region amounts to over half of the world's production. The output of each of the important producing regions has varied considerably in the last decade, but the total production has increased rather steadily, the increase for the ten years being sixteen per cent.

[1] *Metal Statistics*, 1918, p. 253; also *Mineral Resources of the U. S.*, 1904.

The great bulk of tin produced in the Peninsula comes from the Federated States. The Straits Settlements, however, occupies the dominant position in tin output, because of the enormous smelting industry which has been built up at Singapore and Penang for the reduction of ore mined in that part of the world. In addition to the tin obtained from the extensive mining operations in the Federated and Non-Federated States, large quantities of tin ore are imported into the Straits Settlements for smelting purposes from the Dutch East Indies, Siam, Australia, and other tin producing countries. The tin actually mined in the Peninsula in 1915 amounted to 50,876 tons and in 1916 to 48,253 tons. Comparison with Table II shows that the exports from the Straits Settlements exceeded the production in the Peninsula by 17,913 tons in 1915 and 16,948 tons in 1916.

A growing interest in rubber production in which there have been very large profits is said to have seriously curtailed production in certain of the States. Large numbers of coolies have been attracted to rubber estates by higher wages, thus decreasing the available supply of mine labor.

TABLE I—WORLD'S TIN SUPPLIES (a)

(Gross Tons)

	Shipments								
Year	Straits Settlements	Australia	Bolivia	South Africa	China	Banca Sales in Holland	Billiton Sales in Java	Cornwall Production	Total
1908	60,500	5,850	17,000	1,700	.....	11,500	2,200	5,400	104,150
1909	58,500	5,350	18,000	3,000	.....	11,600	2,200	5,600	104,250
1910	54,600	4,650	17,550	3,000	2,200	13,500	2,200	5,800	103,500
1911	55,100	4,000	22,600	2,900	2,500	15,000	2,200	5,300	109,600
1912	59,000	3,800	21,200	3,100	3,800	16,000	2,200	5,500	114,600
1913	62,500	3,200	24,850	3,200	2,450	14,800	2,200	5,800	119,000
1914	63,000	1,800	18,750	5,000	1,900	9,300	1,250	6,000	107,000
1915	66,500	2,550	23,000	5,500	3,000	14,350	1,900	5,000	121,800
1916	61,600	2,650	(b) 19,400	6,000	(c) 2,800	17,800	2,500	4,500	117,250
1917	(d) 62,366	(e) 1,483	24,058	6,650	5,748	(d) 15,209	(d) 1,304	4,100	120,918

(a) From *Metal Statistics*, 1918, p. 253. The figures do not agree with British figures given in Quinn's "Metal Handbook and Statistics," 1917, possibly because of being made up on a slightly different basis.
(b) 15,100 tons to Europe, 4,300 tons to United States.
(c) 1,300 tons to Europe, 1,500 tons to United States.
(d) Partly estimated.
(e) Arrivals in the United States.

Table II gives the exports of tin from the Straits Settlements, by principal countries of destination, for the years 1915 and 1916, according to the official returns:

TABLE II—TIN EXPORTS FROM STRAITS SETTLEMENTS (a)

Destination	Quantity (Gross Tons) 1915	1916	Value 1915	1916
United Kingdom	22,724	25,074	$17,245,070	$21,580,909
United States	32,286	28,100	24,378,322	23,715,938
Philippine Islands	1	304	1,095	264,754
France	4,697	4,248	3,503,127	3,602,767
Italy	1,938	2,063	1,460,031	1,739,556
Russia	4,147	1,713	3,150,490	1,413,128
Spain	180	343	135,625	292,202
China	130	16	97,283	13,420
Japan	949	1,195	726,646	1,012,111
India	1,357	1,384	1,031,101	1,182,265
Other countries	378	761	282,400	627,159
Total	68,787	65,201	$52,011,190	$55,444,209

(a) *U. S. Commerce Reports*, October 8, 1917.

The tin which comes to this country is chiefly in the form of bars, blocks, pigs, or grain and granulated tin.

The country from which tin is imported, according to the return of the United States Bureau of Foreign and Domestic Commerce, is not necessarily the country of origin. Imports from the Netherlands are re-exports from the Dutch East Indies. Similarly, a considerable amount of the tin shipped from the United Kingdom is Straits tin, or the product of other mines which has come through British ports. In 1917, sixty per cent of our tin was mined in the Straits Settlements, sev-

enteen per cent in Banca and Billiton, and eleven per cent in England.[2]

Table III shows the imports of tin into the United States by countries, from 1908 to 1918, inclusive. In this table our importation of tin ore is not included:

TABLE III—IMPORTS INTO THE UNITED STATES, 1908 TO 1917 (*a*)

(Gross Tons)

Year	Germany	United Kingdom	Netherlands	Dutch East Indies	Straits Settlements	Hongkong	Australia	All Others	Total
1908	659	24,650	244	.....	8,600	14	76	264	34,507
1909	975	24,142	335	.....	14,816	151	170	91	40,680
1910	1,989	25,272	372	.....	16,819	484	143	70	45,149
1911	2,341	26,967	1,857	.....	13,472	820	507	214	46,178
1912	1,771	29,513	1,808	.....	14,855	852	210	636	49,645
1913	1,378	23,366	1,576	.....	22,698	1,396	179	620	51,213
1914	1,834	23,674	369	25	17,481	1,013	130	196	44,722
1915	224	20,495	130	1,620	19,265	329	117	170	42,350
1916	....	18,630	...	6,351	36,432	1,830	150	886	64,279
1917	....	18,726	...	11,557	25,098	2,264	1,334	2,439	61,418
1918	....	13,211	(*b*)	10,285	25,084	6,037	3,255	2,924	60,946

(*a*) From U. S. Bureau of Foreign & Domestic Commerce, Commerce and Navigation of the U. S., 1911-1916, and Monthly Summaries of Foreign Commerce of the U. S., June, 1918.
(*b*) No method of determining whether included in "All Others."

It will be observed that our imports of tin increased steadily from 1908 to 1913. In 1914 and 1915 there

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was a decided falling off. In 1916, however, our imports not only recovered, but exceeded all previous records. In 1917 and in 1918 our imports declined from the high level of 1916 but were substantially greater than in 1915 or any preceding years. The effect of the war on shipping routes, which will be discussed later, is clearly shown in the above table. Prior to 1914 we received no tin directly from the Dutch East Indies, but received it by way of the Netherlands. Since the war the Dutch East Indies has been shipping to us directly.

Interesting to note is the fact that while in 1914 our importations of tin from the United Kingdom and from the Straits Settlements formed 90 per cent of the total, in 1918 they amounted to only 63 per cent of the total. The loss was in a large degree offset by heavier shipments from Hongkong, Australia and the countries not separately shown.

It should be noted that total imports of metallic tin for 1918 including the tin content of the ore imported, were said to set a new high record and to total 69,731 tons as compared with 67,529 tons in 1916. Our importation of tin ore previous to the fiscal year 1916 was so small that it was not reported separately by the Bureau of Foreign and Domestic Commerce. Owing to the absence of smelters in the United States, until very recently we could not bring South America tin direct from the Bolivian mines. Instead, ore had to be shipped to Europe or the East for smelting before any of it found its way into the markets of this country.

In the fiscal year 1916, 5415 tons of tin ore were received from South America, and two tons from Panama. During the fiscal year 1917 we imported 5120 tons, and in 1918, 14,816 tons. According to figures recently compiled by the Bureau of Foreign and Domestic Commerce, our 1918 tin ore imports were equivalent to 8,785 tons of metallic tin and thus "approximately 13 per cent of our 1918 imports came to us in the form of ores, mostly from Bolivia."[3]

World Consumption

It is not possible to get exact data on tin consumption, but the amount of tin stocks in the chief markets of the world may be compared from year to year. Such comparison should serve at least to show whether production is increasing faster than the demand for tin, or whether tin stocks are being depleted through a rate of consumption faster than the rate of production.

Table IV shows stocks of tin in London, Holland and the United States (exclusive of Pacific ports) at the close of each month, from 1913 to 1917, inclusive. The stocks fluctuate widely, but it can be seen that there is no very marked tendency towards an increase or a decrease. The consumption is evidently about keeping pace with the production, and *vice versa*.

TABLE IV—WORLD'S STOCKS OF TIN (*a*)

(Gross Tons)

Month	1913	1914	1915	(*b*) 1916	(*b*) 1917
January	4,648	9,609	5,454	5,506	6,368
February	3,779	8,067	4,039	3,906	6,949
March	4,780	10,189	6,345	5,293	7,036
April	4,029	10,056	8,540	6,626	5,745
May	5,962	9,927	4,877	6,849	8,165
June	3,564	8,776	4,761	7,124	5,270
July	5,332	8,648	4,014	8,887	5,854
August	3,472	8,257	6,346	8,892	6,860
September	6,218	8,728	8,223	8,799	5,638
October	4,999	5,625	5,379	7,164	7,472
November	6,741	4,558	4,848	7,560	6,483
December	6,384	4,926	5,274	7,801	4,977
Average	4,992	8,114	5,675	7,034	6,401

(*a*) From *Metal Statistics*, 1918, p. 265.
(*b*) Includes stocks at U. S. Pacific ports.

Tin Consumption in the United States

A decided increase in our tin consumption took place in 1916 and 1917.[4] This increase is not only absolute, but the percentage of the world's consumption which was consumed in this country increased from forty-two per cent in 1915 to fifty per cent in 1917. Whether this is a temporary condition which will readjust itself after the war is impossible to predict, but the war has evidently caused a lessening of the manufacture of tin products in Europe and a corresponding stimulation of the industry in this country.

At the present time, a much larger share is consumed by this industry. Exact data are not available, but it is likely that the quantity so used approximates two-fifths of the total amount of tin used in manufactures in this country. Before the war, during 1912 and 1913, about one-third of the total amount of tin consumed was used in the production of tin plate. Our production of tin-plate, terne plate, and taggers' tin, has increased from 1,153,097,000 pounds in 1908 to an estimated 3,360,000,000 pounds in the calendar

[2] *Metal Statistics*, 1918, page 269.

[3] *U. S. Commerce Reports*, July 31, 1918.

[4] *Metal Statistics*, 1918, page 259.

year, 1917. Our net imports have declined so as to be almost negligible, while exports for 1917 are over 15 times what they were in 1908. There was no great increase in tin-plate retained for consumption up to 1917 but during the year just past, our consumption of tin-plate increased very decidedly, the consumption for the year 1918 exceeding that for the year 1917 by more than twenty-five per cent.

Table V shows the marked increase in our tin-plate industry:

TABLE V—TIN PLATES, TERNE PLATES, AND TAGGERS' TIN (*a*)

(In Thousand Pounds)

Year Ending June 30	Production (*b*)	Exports	Net Imports	Total Retained for Consumption
1908	1,153,097	33,623	140,681	1,260,155
1909	1,203,075	11,411	117,301	1,308,965
1910	1,370,788	26,168	154,369	1,498,889
1911	1,619,005	70,199	95,320	1,644,126
1912	1,756,070	181,899	6,230	1,580,401
1913	2,157,055	164,362	28,331	2,021,024
1914	1,845,130	105,900	48,871	1,788,101
1915	2,085,980	179,221	9,992	1,916,751
1916	2,365,296	516,257	1,789	1,850,828
1917	2,766,400	521,861	1,358	2,255,897
1918 (*c*)	3,360,000	563,068	71	2,797,003

(*a*) From a Statistical Abstract of the U. S. and June, 1917, Summary of Foreign Commerce of the U. S.
(*b*) Production is for the calendar year preceding the fiscal year.
(*c*) Estimated, from *Iron Age*, Jan. 3, 1918, page 65

Our net imports, that is to say, the difference between our total imports of tin plates, terne plates and taggers' tin, and the amount of tin foreign plates and taggers' tin were not very large as compared to our production in any of the years shown in the table, but they have fallen off very markedly since the outbreak of the war.

The expansion of our exports is primarily due to the fact that those European countries normally producing tin-plate for export have been compelled by the war to apply their productive efforts in other directions.

The manner in which the United States has taken advantage of markets thus available is shown by Table VI:

TABLE VI—U. S. EXPORTS OF TIN PLATES, TERNE PLATES, AND TAGGERS' TIN, 1908 TO 1917 (*a*)

(Gross Tons)

Year	Canada	Argentina and Brazil	United Kingdom	China	Hong-kong	Japan	British India	All Other	Total
1908	13,888	127	.....	81	....	343	....	571	15,010
1909	3,441	17	1	328	188	.....	7	1,112	5,094
1910	10,618	36	1	57	24	1	....	945	11,682
1911	20,544	999	.....	3,212	1,099	708	1,888	2,889	31,339
1912	37,801	5,984	298	9,812	4,678	4,239	8,523	9,870	81,205
1913	52,044	5,865	.....	2,234	1,189	1,239	456	10,349	73,376
1914	32,663	2,082	.....	4,012	1,505	192	9	6,813	47,276
1915	34,196	10,343	.....	10,223	2,904	2,074	3,012	17,258	80,010
1916	52,395	29,673	29,784	15,808	14,259	24,638	20,334	43,581	230,472
1917	59,654	36,854	8,696	13,642	9,897	20,728	17,786	65,717	232,974
1918	55,853	47,395	1,332	6,385	10,349	36,021	9,960	84,076	251,371

(*a*) From U. S. Bureau of Foreign & Domestic Commerce, Commerce and Navigation of the United States, 1911, 1916, and Monthly Summary of Foreign Commerce of the U. S., June 1918.

Considerable irregularity is to be noted in our tin-plate exports up to and including the fiscal year 1915. Exports for 1916, however, amounted to three times the total for 1915. Canada is and has always been our single largest customer for tin-plate, but the increase in our exports to Canada was not so marked between the outbreak of the war in the fiscal year 1915 and in 1916 as was the increase in exports to the United Kingdom, to Japan, and to British India.

Export license requirements discussed elsewhere went into effect on Oct. 24, 1917. In spite of these restrictions our exports for the fiscal year ending June 30, 1918 increased eight per cent to 251,371 tons over the exports in the preceding fiscal year. We exported less tin and terne plates and taggers' tin to Canada, the United Kingdom, China and British India, but more to Argentina and Brazil, Hongkong, Japan, and the countries grouped in the classification "All others."

International Relations

Under an agreement recently reached by representatives of the United States, Great Britain, France, and Italy at conferences held in London, each of these countries will get its needed supply of pig tin. The action amounts to an international monopoly of a beneficent nature.

The plan of distribution worked out allows the United States about 80,000 tons of pig tin or two-thirds of the world's entire production annually.

With the War Industries Board supervising the allowance to this country, all imports of pig tin, in ores and concentrates will be consigned to the American Iron and Steel Institute which will receive pay for and distribute the metal to the industry through the United States Steel Products Co.

The price will be regulated by the War Industries Board and will be uniform to consumers of 10 tons of pig tin or over. There will be another uniform price for users of less than 10 tons. These prices will be maintained at a level which will encourage production in the tin mining countries—Great Britain and the Straits Settlements chiefly—and stop profiteering. Prices, rules, and regulations will be announced later. It is probable that users and dealers may be licensed.

The War Industries Board believes there will be insured by these arrangements a steady supply of material at a stable and reasonable price. Since the negotiations for the pooling arrangement began in London six weeks ago the price of pig tin has fallen steadily. The quotation of Sept. 6 last showed a net decrease of 14 cents per pound as compared with the price on July 15, 1918.[*]

Within the last year complications with Holland have threatened to tie up tin shipment from Banca and Billiton. On April 22, 1918, Holland imposed an export license on tin and tin ore leaving the Dutch East Indies, but it is understood that this is not at present to interfere with traffic with the United States.

Government Control

The export of tin-plate from the United States was first restricted by regulation of the War Trade Board

[*] *Official Bulletin*, September 11, 1918.

announced on October 24, and amplified on November 12, 1917. According to these rulings, all exports of tin plate and articles containing tin were placed under license, whose issuance was carefully regulated by the proof in each case as to the use to which the goods were to be put. Preference was given for the exportation of tin-plate for use for any other purpose than as food containers, or of articles other than tin-plate, containing tin, except on satisfactory evidence that the goods would be used in such a way as to contribute to the military needs of the nations at war with Germany and her allies. Licenses might be granted for the exportation of articles other than tin-plate containing tin, if the goods would be used to contribute to vital needs other than military of the nations at war with Germany and her allies. No license was to be granted except to manufacturers, or others who could present satisfactory evidence that they had purchased the plate from a manufacturer on firm order from a purchaser abroad.

On March 6, 1918, further restriction on the exportation of tin and terne-plate was announced by the War Trade Board, with the object of directing the supply

VICTORIA CONCENTRATING WORKS, AUS TIN MINE

for the benefit of the allies. The rules announced supplement those already in force and are as follows:

Licenses may be granted to manufacturers of tin-plate and terne-plate or to persons other than a manufacturer, provided the purchase of the plate has been made directly from a manufacturer prior to November 12, 1917, and also provided such purchase has been made to fulfill a contract or firm order from a purchaser abroad placed with a firm in the United States, a copy of which must be annexed to the application. Export licenses for tin-plate or terne-plate may be granted only for shipment to Canada, South and Central American countries, including Mexico and the West Indies, China and Japan, and only when the plate is to be used either—

1. To manufacture containers for edibles for human consumption by the people of the nations at war with Germany and her Allies, or

2. To manufacture oil cans, provided the plate has been ordered from the mill on or before August 27, 1917. In this case there shall be no distinction between purchases from manufacturers and purchases from others, or

3. When the plate is to be shipped to any of the above mentioned countries except Canada, it is to be used for purposes which shall contribute directly to the successful prosecution of the war, or

4. When the plate is destined for Canada it is to be used for purposes for which tin-plate or terne-plate is now permitted to be used in the United States.[1]

Despite these regulations, export figures, as already noted, indicate no noteworthy reduction in our exports of tin-plate. Exports to the Allies constitute an essential part of the war programme. For example, the French Government has proposed an exchange of services for 1918 whereby France will undertake to pack enough canned goods for herself and for the American forces abroad, provided the United States will furnish the tin-plate. The labor will largely be performed by women and it is estimated that the saving in ocean tonnage will be considerable. Exports to neutrals, and to countries not actively assisting the Entente Allies in the prosecution of the war totalling perhaps 50,000 tons for the fiscal year just closing, are difficult of explanation in the face of the apparent tin shortage.

In the absence of Government price control, tin prices have naturally reflected the scarcity which has existed for so many months, both in this country and in England. Prices have gone far above all previous records. In this country the virtual absence of spot tin has made price a more or less theoretical question, but it is safe to say that tin prices have doubled in the last two years.

Table VII shows the trend of tin prices on the London market for the years 1911 to 1917, inclusive:

TABLE VII—MONTHLY AVERAGE PRICES OF TIN IN LONDON (*a*)

(Cents per Pound)

Month	1911	1912	1913	1914	1915	1916	1917
January....	40.71	41.65	49.64	37.38	34.04	38.20	40.48
February...	41.20	42.42	47.86	39.45	38.47	39.36	43.23
March.....	39.63	41.87	46.40	37.80	39.22	42.08	45.09
April.....	41.94	43.54	48.82	35.67	36.17	43.54	47.84
May.....	42.97	43.52	48.82	32.80	35.40	42.73	53.26
June.....	45.06	44.74	44.44	30.16	36.47	39.03	52.66
July.....	41.95	43.97	39.94	30.96	36.35	36.60	52.65
August.....	41.39	45.22	41.05	30.21	(*a*) 32.94	36.93	53.00
September..	39.29	48.66	42.01	29.47	(*b*) 33.22	37.24	53.00
October....	40.66	49.63	40.19	28.01	(*b*) 32.98	38.98	53.76
November..	42.36	49.50	39.32	30.13	(*c*) 36.48	40.62	59.78
December..	44.18	49.29	37.35	31.98	36.32	39.86	64.87
Average..	41.78	45.33	43.82	32.84	(*c*) 35.67	39.58	51.64

(*a*) From *Metal Statistics*, 1918, p. 279.
(*b*) Based on private transactions.
(*c*) Based partly on private transactions.

These prices vary rather markedly from the New York prices as shown below. The variations were minor, however, before the shipping crisis became so acute, the difference becoming greater as the difficulties of shipping increased.

Measures to Reduce Consumption of Tin

Until war conditions forced the subject upon us, no attention had been paid in the United States to the conservation of tin. The danger of a tin shortage in the

TABLE VIII—PIG TIN PRICES IN NEW YORK (*a*)

Monthly Average Prices of Straits Tin in New York
(Cents per Pound)

Months	1911	1912	1913	1914	1915	1916	1917
January....	41.39	43.24	50.45	37.74	34.30	41.88	44.19
February...	42.83	43.46	48.73	39.93	37.32	42.63	51.37
March.....	40.76	42.86	46.88	38.08½	40.93½	50.42	54.36
April.....	42.20	44.02	49.12	36.10	47.98	51.75	55.91
May.....	43.10	46.12	49.14	33.30	38.78	49.15	63.29½
June.....	46.16	47.77	44.93	30.65	40.37	42.18	62.09
July.....	42.96	44.75	40.39	31.75	37.50	38.46	62.60½
August.....	43.45	45.87	41.72	50.59½	34.39	38.54	62.69½
September..	39.98	49.18	42.47	32.79	33.13	38.70½	61.69
October....	41.21	50.11	40.50	30.39½	33.08	41.16	61.81
November..	43.13	49.90	39.81	33.50	39.37½	44.17	74.44
December...	44.97	49.90	37.64	33.60	38.75	42.66½	(*b*) 85.35
Average..	42.68	46.43	44.32	35.70	38.66	43.48	61.67

(*a*) From *Metal Statistics*, 1918, p. 277.
(*b*) Market strictly nominal December 12 to 31; 86.00c. used for those dates as arbitrary basis in computing the month's average.

[1]New and more complete regulations were issued by the War Trade Board (W.T.B.R. 209) too late to be included in this article. The changes from the above consist mainly in classifying the exports and giving specific instructions as to procedure.

food packing industry was recognized in the Spring of 1917 and, by voluntary agreement, packers of non-perishable foods stopped running during June and July in order to insure an adequate supply of tin cans for the perishable crop then coming on. Since that time conservation in various directions has been urged and, to a degree, has taken place.

The conservation of tin plate is of prime importance. According to the War Trade Board, "That there may be a sufficient supply of tin in the United States to meet the war needs and to supply essential civilian uses, vigorous plans for conservation of the metal are being made effective through coöperative efforts by the War Industries Board and by the Food and Fuel Administrations in the enforced substitution of other than tin containers, wherever that is possible. Tin container manufacturers have agreed with the War Industries Board in plans that will curtail their use of tin plate 13 per cent which means a saving in the next three months of about 150,000 tons of tin plate.

The Food Administration is working out a tin conservation plan with various industries, including lard and lard compound packers, wholesale grocers, cracker manufacturers, tea and coffee packers, cocoa and chocolate manufacturers, and baking-powder manufacturers. All have been urged to substitute fiber, paper, or other containers where possible.

The Fuel Administration has taken up the subject with the oil dealers and the War Industries Board is working along similar lines with the tobacco manufacturers and all industries in which tin is used in turning out the finished product.[6]

The substitution of other materials for tin containers has gone much further abroad than it has in the United States, and the possibilities in this direction are great. During August, 1917, a cardboard container was developed in Great Britain for use in packing army jam. Since that time its manufacture has been so developed and extended that there is now an output of 5,000,000 cardboard containers per week. The bulk of these are two-pound size, but a proportion are of one-pound and five-pound sizes and all three are used as substitutes for tin packages. Since last September, in Great Britain, dried foodstuffs and semi-liquid foods have not been "permitted to be packed in tin-plate, nor has fruit. The use of terne-plate for lining packages for the export of textile and other goods has also been prohibited, and where use of tin-plate could not be wholly stopped, economies were attempted by insisting upon the use of larger containers for packing meat and canning milk. The size of oil cans was doubled, and in India tinned iron drums were brought into use for petroleum products.

"At the present time tin containers are practically used only for meat and processed foodstuffs. Most of the paper or cardboard containers employed have been largly of the kind known as composite containers, i.e., having tops and bottoms of tin, but it is expected to soon perfect the manufacture of these containers so as to be able to make them all paper products.

"Efforts have been made to introduce substitutes in the army. Cardboard, wood and fiber are now substituted for tin-plate in the manufacture of such things as card-index boxes and workmen's checks, while earthenware bowls are used instead of the old pudding bowls. Salt, sugar and tea, which formerly were packed in soldiers' rations tins, are now packed in paper bags. Recent regulations of the Ministry of Munitions have put the civilian trade upon a very strict ration, so that there will only be a bare minimum supply of essential articles, such as domestic utensils, stoves, meters and lamps."[7]

While this saving in tin-plate in Great Britain has been primarily for the purpose of conserving steel rather than tin, the result has been to save a large amount of tin.

The Australian Government has forbidden the use of tin-plate for the making of many articles, chief of

SMELTING WORKS AT MIRAFLORES, UNCIA

which are the containers for boiled sweets, for packing butter in quantities less than two pounds, except for war purposes and for dispatch to soldiers abroad, for the making of second lids for containers of butter and cheese and for use in the manufacture of stoves, phonograph horns and kerosene pumps. That Government has also forbidden the replenishing of stocks of articles made of tin-plate more than is necessary for three months' use, and has forbidden the importation of a number of articles made of tin plate and of many other articles when packed in tin plate.

Reduction of the amount of tin used for purposes other than the manufacture of tin-plate has not been overlooked.

The quantity of tin absorbed in the manufacture of silks is so large that the Government is taking cognizance of the fact. The tin used for this purpose is largely recovered metal, converted into tin tetrachloride and sold to silk dyers for weighting and finishing the fabric. The aggregate amount of tin per year used in the United States for the weighting of silk is not known, but estimates of as much as five thousand tons have been made. The use of tin for weighting is detrimental to the wearing qualities of the silk, and is the chief cause of cracking. It is the purpose of the Government to reduce the amount of tin used in the silk industry to a minimum.

The substitution of lead-base babbitt metal for tin-base babbitt metal, and the reduction of the tin content

[6] *Official Bulletin*, September 11, 1918.

[7] *Journal of Commerce*, N. Y., July 15, 1918.

of the tin-base babbitt metal is being urged, as well as economical use of babbitt metal. The Bureau of Standards has completed an investigation of bearing metal and has suggested elimination of all but four grades. It is stated that a saving of about 25 per cent in amount of tin will be affected. Large savings have already been made by automobile and other machine manufacturers by substituting for all metal bearings, case bearings with thin lining shell $\frac{1}{16}$ to $\frac{1}{32}$ of an inch high grade babbitt. Straits tin is often specified on the assumption that it is the purest tin. Banca is even purer than Straits or Australian, and electrolytic tin is as pure.

Reduction of the percentage of tin in alloy castings to the lowest possible figure is being advocated, and the substitution wherever possible of a mixture of lead and tin solder for pure tin solder. The Bureau of Standards is making investigation of solder along the same lines as its investigation of babbitt metal. It is stated that "the can companies have reduced the percentage of tin in their solder to forty, thus saving eight to ten per cent without injury to the industry."

"A plan was suggested and is now being perfected for the recovery of a large part of the tin used in foil and tubes. Through a campaign of advertising through notices on the packages and other methods, consumers of articles packed in foil or tubes will be induced to save those articles and turn them in at the nearest Red Cross center as donations. Smelters and other users of tin will then purchase at market rates the lots thus collected by the Red Cross. It is estimated that this will recover some 3000 to 5000 tons of tin per annum and bring the Red Cross an added income of from $4,000,000 to $5,000,000."[1]

The possibility of the utilization of empty cans and of the tin in them is also being considered. Oil cans sent from this country to the Orient have been used there for some time in making an inconceivable number of articles—lamps, cook stoves, pots, pans, sprinklers, toys, bottle caps, dust pans etc. The possibility of a notable saving in this country by a similar utilization is now being considered. The Department of Commerce has urged upon State Councils of Defense, Chambers of Commerce and other trade organizations the consideration of the collection of old tin cans before they have rusted, in order to sell them to detinning companies. It is hoped that a considerable amount of tin can thus be recovered. The Food Administration has also advocated the straightening and retinning of dairy cans as a means of saving the tin-plate. Such cans can be renewed at from one-fourth to one-third the cost of new ones.

Shipping Routes for Tin

Prior to the war, London was the center of the tin trade of the world. The ruling prices on the London market governed the value of all other grades of tin. Great Britain controls not only Singapore and Penang, from which Straits tin comes, but the Chinese product, which is shipped from Hong Kong. Her control was complete at these ports, not only because of political dominance, but because nearly all the vessels in the tin trade were of British register.

Great Britain made it a definite policy to confine the tin trade as far as possible to London, and for this reason all consignments destined from Singapore or Penang for America had to come via London, and thence across the Atlantic, though the direct route would have been via the Pacific to San Francisco. Bolivian tin is partly smelted in that country, but prior to the erection of tin reduction works here, much of it was sent to English smelters, and thence to the United States.

The increasing facilities for smelting the tin here will effect an important economy in this shipping. It is reported, moreover, that the Tin Committee of the Council of National Defense has arranged for the direct shipment of tin from the Straits Settlements to the Pacific coast.

Tin, even after it arrived in this country, was customarily subjected to unnecessary shipments. Consignments arriving at the Pacific coast would be bonded to New York, cleared at the Custom House there, and often shipped half way back across the continent to consuming points in the Middle West. The practice was not only expensive, but it led to considerable congestion at the terminal points in New York and to traffic delays in the journey. To reduce such difficulties to a minimum, the Sub-Committee on Pig Tin of the American Iron and Steel Institute has recommended to the tin trade that consignments be passed through the Custom House at the Pacific ports or, if this be impracticable, that they be shipped in bond to Chicago, Pittsburgh, or other convenient points of distribution.

Only once before the beginning of the war had our total imports of tin exceeded 50,000 tons. This was for the fiscal year ending June 30, 1913, when we received 51,213 gross tons. Our average imports for the five fiscal years preceding the outbreak of the war were less than 50,000 tons.

Our total imports of metallic tin for the fiscal year just ended amounted to 69,731 tons, the highest figure in our history. The inter-allied pooling agreement in allotting us 80,000 tons annually seems to have provided amply for our needs. Of course, the fact that this country has been "allowed" 80,000 tons does not necessarily mean that we will import that much tin. Nevertheless it is an indication that a more plentiful supply may be expected. Normal conditions cannot be hoped for until the close of the war, but reasonable conservation and skillful distribution may be expected to meet the present situation so successfully as to minimize the effects of the disturbing factors which are now affecting the supply of and demand for tin.

Bolivian Tin Profits.—The gross profits of the Llallagua Tin Company, of Bolivia, for 1917 was £1,712,170, against £466,123 in 1916, the dividends distributed absorbed £637,500, while £850,000 was allocated to future dividends. The capital of the company is £425,000, the interest and dividend reserve total £850,000, and other reserves £466,000. The production of concentrates increased from 7460 long tons in 1916 to 11,250 tons last year. The costs of production, etc., were less in 1917 than in 1916, being last year about £36 a ton in 1916. The largest increase was shown by the Llallagua Company, which ranks second as a producing company, being surpassed only by the Patino Company, whose last year's output was 13,300 tons of concentrates, against 10,000 tons in 1916.

[1] *Official Bulletin*, June 24, 1918.

Testimonial to Dr. M. C. Whitaker

WHEN Dr. Milton C. Whitaker retired from the presidency of the Chemists' Club his fellow officers and trustees gave him a silver service in appreciation of his remarkably able administration of the club's affairs. Inasmuch as there was a surplus left after the purchase of the silver, Messrs. Ellwood Hendrick, the succeeding president, Thomas R. Duggan, chairman of the house committee and Dr. Bernhard C. Hesse, conceived the idea that it would be well to add something more personal with the remainder. With the consent of the donors they engaged Mr. Edward B. Edwards to design the memorial of which we give an illustration herewith.

It is framed so that both sides may be seen, the reverse containing the record in English and the names of the donors. The beautiful Latin text is from the pen of Professor McCrea of Columbia University. The English text, which is freely translated, reads as follows:

> We, your fellow officers and trustees of the Chemists' Club during the term of your presidency, recognizing your great service in directing its affairs with signal ability and rare foresight, present this minute of our sincere appreciation.
>
> New York, May 1st, 1918.

The memorial is of peculiar interest in that alchemistic symbols are employed in the decoration. In the four corners are vignette portraits of Geber, Roger Bacon, Raymond Lully and Paracelsus copied from an old French work. In the centre of the top border is the emblem of the Chemists' Club, a benzene ring enclosing a salamander and a flame. The alchemistic symbols in the border beginning at the upper left hand corner and reading around to the right, are as follows: Gold, Fire (Chemists' Club Emblem), Air, Silver, Copper, Tin, Sulphur, Water, Vitriol, Mercury, Lead and Iron. The scheme of decoration is a very happy one and lends itself to the embellishment of halls and buildings devoted to chemistry.

Traditions are beginning to apear at the Chemists' Club. There is a little copper container for coffee which has engraved upon it "The President's Pot," prsented a couple of years ago by Mr. Lane of the U. S. Appraisers' laboratory, to distinguish the incumbent of the presidential office. Dr. Whitaker refused to turn it over on his retirement without, as he declared, the proper ceremony, and he lately invited the trustees to dine with him at the club before their meeting, to witness him endow it upon his successor for the term of his incumbency.

On receiving his official decoration President Hendrick responded as follows:

> This copper Presidential Pot
> Is singular in that it's got
> The function of entailment meant
> For each succeeding President.
>
> Now let's engrave upon it well
> The name of Whitaker to tell
> That it was he who was the first
> To quench his presidential thirst
> From it, when as he broke his fast,
> And also, when the day was past,
> To fill from it his little cup
> To liven his digestion up.

Then underneath we lesser men
May follow him as now and then
We serve each one his little day
And, having done so, fade away.

This pot, from which I hope to drink
My fav'rite coffee, black as ink,
Is mine in trust but for the span
That I'm entitled to the can.
It is not part of my estate.
And yet I certainly should hate
To have it used by any slob
So long as I hold on my job.

This is not spoken as a threat
Because I've hardly got it yet.
I merely mention it because
It is not written in the laws
And I don't want to strew my path
With tokens of unholy wrath.

And now I offer you this toast
For those who really need it most:
May every one who stays his thirst
From this pot, emulate the first
To use it. May he stir
The Club's dry bones like Whitaker,
Employing wisdom, judgment and
The requisite amount of sand,
Without once ever letting slip
His standard of good fellowship.

From A to Z With the Exhibitors

PROVOST ENGINEERING COMPANY. Filter presses. Particular developments since the United States entered the war are special filter presses for acids. In charge of exhibit: J. A. NAUGLE, C. A. BEACH.

QUIGLEY FURNACE SPECIALTIES COMPANY, INC. Demonstration of the use of hytempite furnace cement, in a small high-temperature electric furnace. A new insulating brick will also be thus demonstrated and samples of Kieselguhr will be shown. In charge of exhibit: W. S. QUIGLEY, C. P. GANTZMAN, F. J. SPILLANE, J. H. MCPADDEN.

RARITAN COPPER WORKS. Products showing the various stages of smelting and refining copper from the ore to commercial bars, together with by-products of the electrolytic refining of copper bullion, such as nickel sulphate, copper sulphate, selenium, tellurium, silver, gold, palladium and platinum. Anaconda electrolytic zinc, common copper, corroding lead and an antimonial lead will also be shown. The production of electrolytic pure zinc has been accomplished since the war began, and has had an important bearing on high-grade munitions. In charge of exhibit: S. SKOWRONSKI.

RAYMOND BROTHERS IMPACT PULVERIZER COMPANY. A full line of pulverizing machinery equipped with air separation. Three of the models are one-quarter size of the actual mill, but the fourth will be of the actual size such as is used in the chemical, dry color and dyestuffs industries. All will be in operation in such a way as to show the actual workings of the mill for any particular purpose. In charge of exhibit: R. A. LACHMANN.

RESEARCH CORPORATION. A complete set of samples of the different materials collected by the Cottrell processes, so arranged to indicate the use of processes in particular industries. Special emphasis is laid on the use of the processes in connection with those industries that are vital to the prosecution of the war, such as acid plants, steel works, potash recovery plants, etc. Since the beginning of the war the use of the processes in the sulphuric acid industry has been greatly expanded and has been successfully applied to the cleaning of hot sulphur dioxide gases from roaster furnaces and for the recovery of acid mist from the exit gases from concentrators. The application of the processes for the cleaning of iron blast furnace gases, which is a successful means of recovering potash, manganese and other valuable constituents. In charge of exhibit: H. D. EGBERT.

REVOLVATOR COMPANY. Rovolving and non-revolving types of the revolvator. This equipment is of unusual interest at the present time in view of the labor shortage for handling materials. The Government requirement of piling materials to the roof of box cars has opened a new field for this device.

ROESSLER & HASSLACHER CHEMICAL COMPANY. Chemicals used for electro-plating, case-hardening and heat treating, principally cyanides. There will also be a display of such materials as steel, copper, silver and bronze which are plated, treated and finished with the company's chemical products. In charge of exhibit: Doctor ABEGG.

ROSSENDALE-REDDAWAY BELTING & HOSE COMPANY. Illustrations of drives on which the company's belts are used, and showing the conditions which have to be met in various plants. Some of these belts will also be shown in operation to illustrate features of special interest to the chemical industry. In charge of exhibit: WILLIAM L. CLARKE.

RUGGLES-COLES ENGINEERING COMPANY. A model of a double-shell direct-heat dryer, together with diagrams of different installations of the various types of dryers manufactured. In charge of exhibit: F. E. FINCH.

THE R. U. V. COMPANY, INC. A quartz mercury-vapor lamp and an ultra-violet ray laboratory outfit using this lamp as the source of ultra-violet rays. New features of the outfit will be shown. In charge of exhibit: Mr. RICORD.

SCHAEFFER & BUDENBERG MANUFACTURING COMPANY. Indicating and recording gages of all types, gage testers, indicating and recording thermometers, "reform" mercury actuated dial thermometers, hand and stationary tachometers, counters, steam calorimeters, etc. As a special attraction there will be an exact reproduction 9 ft. high of an industrial thermometer which in reality only measures 14 or 15 in. high. In charge of exhibit: H. V. CARLIER F. UNDEUTSCH, A. WEISS.

SCHAUM & UHLINGER. Nirto cellulose extractors and a laboratory centrifugal. In charge of exhibit: C. W. SCHAUM, A. J. CADY, L. GRISCOM.

SCHUTTE & KOERTING COMPANY.. A display of power plant equipment including injectors for boiler feeds, emergency safety valves, non-returns and a complete line of fuel-burning equipment; apparatus used in the chemical industry for handling corrosive gases or liquids, such as steam jet exhausters and compressors, ventilators, blowers and hard-lead fans, also pumping equipment such as syphons, air jet lifts, centrifugal pumps and automatic blowcases. There will also be spray nozzles of numerous types but particularly the Witclay sulphuric chamber nozzle. A new development since the war began is the Bihn-Jones automatic attachment for blowcases. In charge of exhibit: C. H. KIMBERLY.

SCHWARTZ SECTIONAL SYSTEM. Equipment for systematically arranging and instantly locating chemicals,

reagents, samples, and similar materials which may be kept under ideal conditions free from dust and away from the detrimental effects of light.

SCIENTIFIC EQUIPMENT COMPANY. An exhibit of laboratory instruments and apparatus and laboratory furniture made by the Central Scientific Company and the Kewaunee Manufacturing Company. In charge of exhibit: O. T. LOUIS.

ERNEST SCOTT & COMPANY. Photographs of plant and machinery installed by the company for chemical processes, showing evaporators for various purposes; solvent extraction plant for recovery of grease and oil; caustic recovery plant; glycerine recovery plant for recovering glycerine from fats and oils; glycerine refining plant; soap plant machinery; fish drying plant; fish oil extraction plant; plants for the distillation of water, naphtha, acetic acid, crude pyroligenous acid; apparatus for degreasing skins and hides; plant for the manufacture of electrolytic caustic soda and caustic potash. New features developed since the war comprise equipment for the manufacture of pure ammonia from gas and coke oven spent liquor. In charge of exhibit: H. AUSTIN.

SEYDEL MANUFACTURING COMPANY. Benzoic acid and its derivatives which the company is manufacturing at the rate of over 1000 lb. per day. There will also be an exhibit of the company's furamine fur dyes together with a collection of furs dyed therewith.

SHARPLES SPECIALTY COMPANY. Super-centrifugal machines, and blueprints showing layouts of processes in which the machines are used. In charge of exhibit: MAX B. MILLER.

SHAWINIGAN WATER & POWER COMPANY. An exhibit of the industries at Shawinigan Falls, Quebec, Canada, comprising calcium carbide, carbon electrodes, magnesium metal and powder, glacial acetic acid and allied chemicals. The last-named article has been developed synthetically from calcium carbide since the beginning of the war. There will be an automatic projecting machine showing the views of exteriors and interiors of the various plants and development at Shawinigan Falls. In charge of exhibit: V. G. BARTRAM.

T. SHRIVER & COMPANY. Two or three of the most popular types of filter presses in as many different sizes. In charge of exhibit: I. R. E. PERRY.

SIDIO COMPANY OF AMERICA, INC. Fused silica ware for laboratory purposes and for use in chemical, scientific, technical and industrial operations. Combustion and pyrometer tubes in all sizes and diameters will be shown, as well as an exhibit of dishes, trays and pipes for the concentration of sulphuric acid. In charge of exhibit: G. H. MULLER, F. H. RUHE.

WALTER SODERLING, INC. "Dustite" respirator for protection of workers in cement plants, color plants, lead works and other industries where irritating and poisonous dust might injure the lungs and membranes of the nose and throat. In charge of exhibit: WALTER SODERLING.

SOUTHERN PINE ASSOCIATION. The prime chemical products derived from Southern yellow pine, with charts explaining the various chemical processes. The various finishes are illustrated in the railing enclosing the booth. Samples of the chemical products, tools and cups used in the turpentine industry will be displayed; a model showing the commercial utilization of an average pine tree from the woods to finished products. In charge of exhibit: L. R. PUTMAN.

SOWERS MANUFACTURING COMPANY. A special 200-gallon full jacketed kettle with special mixer and outlet, developed for mixing 80-20 amatol; standard laboratory vacuum pans; photographs of various equipment. In charge of exhibit: C. M. DEFOREST.

F. J. STOKES MACHINE COMPANY. Rotary compressor in operation making naphthaline moth balls. Small rotary vacuum dryer with patented spiral agitator; dry dust filter and automatic discharge outlets; small laboratory shelf vacuum dryer with condenser and receiver forming a stand; copper vacuum still; automatic combination water still. In connection with war work this company has adapted its compressing machines to the making of pellets of TNT, tetryl, black powder and other explosives. In charge of exhibit: LAWRENCE H. BAILEY.

STUART & PETERSON COMPANY. Plain and porcelain lined chemical ware. The principal feature of the exhibit is the 25-gallon cast-iron enameled still representative of those which are built up to a capacity of 1000 gallons. There will also be on exhibit smaller pieces of laboratory ware. During the last two years this company has developed a large line of special aparatus, but particularly sulphonators and steam jacketed vacuum pans. In charge of exhibit: LOGAN B. MORRIS.

STURTEVANT MILL COMPANY. Machinery for crushing, grinding, screening, weighing, sacking, dry mixing, elevating and conveying, either in full size or working models. One of the features of the exhibit is the "open door" labor-saving accessibility of Sturtevant machinery. In charge of exhibit: L. H. STURTEVANT, H. A. TOMLINSON, W. T. DOYLE, R. M. GAY, D. KANTOR, E. M. YOUNG, J. H. WAYMAN, W. L. DOTEN.

SWENSON EVAPORATOR COMPANY. Evaporators, diffusion batteries, welded digesters, machinery for beet sugar plants. In charge of exhibit, S. W. HIND.

C. J. TAGLIABUE MFG. COMPANY. Automatic apparatus for the control of temperature, pressure, time, liquid level, and condensate. The particular controllers which have been developed since we entered the war are the automatic liquid level and condensate controllers for use on evaporators, paper drying machines, tanks and drying apparatus. There will also be an exhibit of indicating and recording thermometers, hydrometers, oil-testing instruments, hydrophants, barometers, etc. In charge of exhibit: L. C. IRWIN, B. O. PALLIN, H. T. CRUAX, T. T. DOUGHERTY, W. W. WHITE.

TAKAMINE LABORATORY, INC. A display of chemical specialties: Polyzime, used as a desizing agent in the textile industry; Hirathiol, Ichthyol equivalent, imported from Japan; Arsaminol and Neo-arsaminol, manufactured in this country. Among other imported chemicals shown will be potassium ferrocyanide, potassium ferrocyanide, potassium iodine, potassium bicarbonate, resublimed iodine. In charge of exhibit: C. P. CONCANNON.

TAYLOR INSTRUMENT COMPANY. An exhibit in three sections devoted respectively to (A) electrical pyrometers and engraved thermometers and hydrometers; (B) Tycos industrial thermometers; (C) Tycos recording thermometers and pressure gages and Tycos press-

ure and temperature regulators. The pyrometer line will include indicating and recording pyrometers in single and multiple form with special switchboard completely wired and ready for use. Tycos base metal and rare metal thermit couples will be exhibited in a way to show methods of construction. The Fery radiation pyrometer will be demonstrated. Engraved thermometers and hydrometers will be shown in a complete line, with the method of manufacturing demonstrated. Oil-testing apparatus and differential thermometers will form a part of this exhibit. Industrial thermometers will be shown in a wide range of sizes and for a variety of applications. Temperature regulators and controllers will be shown in various types, from the simple controller for maintaining uniform temperatures and ordinary hot-water tanks to the more complicated instruments for regulating temperatures and controlling the time period where the temperature must be advanced by degrees to a predetermined maximum and maintained at that point. Regulators will be on exhibit especially adapted to benzol apparatus. The instruments which have been developed within the past four years, or since the war began, are U. S. Bureau of Mines pattern flash and fire testers for low-burning and high-burning oils. Gasoline distillation apparatus built according to the specifications of the United States Bureau of Mines and American Society for Testing Materials. Tycos differential thermometers constructed in a solid engraved stem pattern.

THERMAL SYNDICATE, LTD. Vitreosil ware for chemical industries and laboratory and research work. This is pure fuse silica in opaque, translucent, and transparent varieties. The features which have been developed during the past year are industrial tubes in 10-ft. lengths; large S bend cooling sets for nitric and hydrochloric acid and transparent tubing and laboratory ware. In charge of exhibit: A. A. MONFRIED, S. L. TYLER, E. J. VANVRANKEN, W. W. WINSHIP.

TOLHURST MACHINE WORKS. Five different types of Tolhurst centrifugal machines having the standard self-balancing feature. The latest type of suspended centrifugal with bottom discharge and 40-in. basket, built for specially heavy duty, will also be shown. The center-flung open-top centrifugal, developed since the war, will be shown in operation. Since the outbreak of the war this concern has developed several types of centrifugals especially designed for the rapid production of munitions. In charge of exhibit: W. C. DUTTON.

UEHLING INSTRUMENT COMPANY. Fuel-saving equipment, CO_2 recorders, combustion recorders, draft recorders. The features of the exhibit are equipment recommended by the United States Fuel Administration. In charge of exhibit: S. W. SMITH.

UNION DYE & CHEMICAL CORPORATION. Samples of dyes, showing the dyeings; samples of dyestuff intermediates and heavy chemicals, the latter being raw products for explosives manufacture which are being supplied by the company to several governments.

UNITED FILTERS CORPORATION. Demonstration of a model of the American continuous suction filter: a large type of filter with approximately 65 square feet of filter area will be exhibited to give an idea of the commercial size machine; an intermediate size of the Sweetland type of filter with a cake capacity of 32 cubic feet of solids; a small model of the Kelly filter; Sweetland patent metallic filter cloth, and a filter lead of the all-metal type. In charge of exhibit: H. J. RUNYON, JR., A. W. SCHMIDT, C. B. OLIVER.

UNITED LEAD COMPANY. "United" lined products, including lead-lined pipes, fittings, valves, centrifugal acid pumps, lead-coated sheets and coils, lead-lined tanks and kettles. The centrifugal acid pumps, lead-coated sheets and some of the valves have been developed since the beginning of the war. In charge of exhibit: C. B. HOLDEN.

UNITED STATES CAST IRON PIPE & FOUNDRY COMPANY. Exhibit of facilities for manufacturing cast-iron pipes and castings used in chemical and allied industries. In charge of exhibit: H. A. HOFFER, C. D. DONALDSON.

U. S. INDUSTRIAL ALCOHOL COMPANY. A display board showing the many uses of alcohol in the arts and industries. Illustration of the company's plants and methods of transporting raw materials and products. An exhibit will be made of the use of alcohol in removal of carbon from cylinders of explosion engines. The products exhibited will comprise ethyl alcohol, cologne spirits, wood alcohol and refined fusel oil. In charge of exhibit: A. H. LESLIE.

UNITED STATES INDUSTRIAL CHEMICAL COMPANY. An exhibit of the company's products, including acetone, methyl acetate, ethyl acetate, amyl acetate, ethyl methyl ketone and light and heavy acetone oils. Photographs illustrating the extent of the manufacturing facilities of the company. In charge of exhibit: E. H. LESLIE.

VALLEY IRON WORKS. Machinery for the chemical and explosive industries, consisting of autoclaves of laboratory and semi-commercial sizes. These machines will be identical in every particular except size with the large commercial apparatus. In charge of exhibit: THOMAS SENIOR, RAYMOND L. RILEY.

WARNER CHEMICAL COMPANY. A full sized model of the Nelson electrolytic cell for the production of chlorine gas and caustic soda. There will also be on exhibit a flow sheet of the products manufactured by the WARNER CHEMICAL COMPANY and the base materials from which they come. The principal thing of interest on this is acetic anyhdride which prior to the war was almost entirely imported from Germany.

WERNER & PFLEIDERER COMPANY, INC. An exhibit of laboratory sizes of "Universal" kneading and mixing machines; a rapid dissolver, laboratory size, hand driven; a new direct motor-driven laboratory grinder, in operation. These machines will be available for tests or experiments which visitors to the exposition may desire to make. In charge of exhibit: EMIL STAEHLE, A. J. VOLLRATH, C. PLETSCHER, EUGENE SCHILLER, J. C. CALEY, S. D. GRIDLEY, J. J. MEGERIAN.

ZAREMBA COMPANY. Evaporators. Owing to the nature of the apparatus in which this company specializes, it is impossible to make an advantageous exhibit, hence the display feature is eliminated. In charge of booth: H. E. JACOBY.

ZAVON, INC. An exhibit featuring the use of Zavon, the textile solvent, in the textile trade as an aid in bleaching, softening and dyeing. This is an entirely new product since the beginning of the war. In charge of exhibit: T. W. PRITCHARD, CHARLES S. SAWYER.